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AIR LAUNCH CHARACTERISTICS OF THE MQM-74C TARGET DRONE FROM DC-130A AIRPLANE

Mark Lempert

Naval Air Development Center
Warminster, Pennsylvania

9 January 1975

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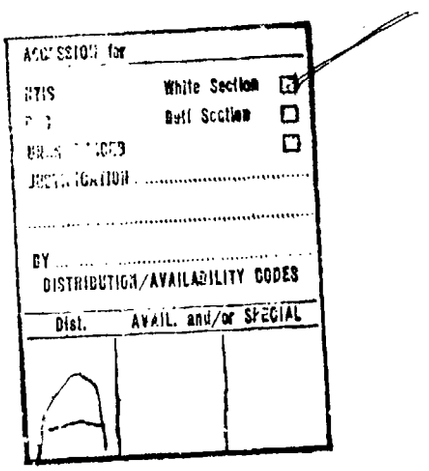

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A six-degree-of-freedom simulation study was conducted to predict air launch separation characteristics of the MQM-74C aerial target drone from a DC-130A. The effects of various launch aircraft flight conditions, flow field effects, autopilot control system malfunction, and loss of engine power on target separation characteristics were analyzed.

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SUMMARY

The predicted separation characteristics of the MQM-74C target drone, when air launched from the DC-130A aircraft, are presented herein.

The analysis was accomplished with the aid of a six-degree-of-freedom digital computer simulation which incorporates analytically estimated airloads on the target in the carriage position, the aircraft flow field (obtained both analytically and from wind tunnel test data), target autopilot and engine characteristics and the basic target aerodynamics.

A predicted safe launch is presented for a target separating from a level flying DC-130A aircraft. Various launch aircraft flight conditions, target pitch commands, autopilot malfunctions with and without engine operation, and locked control surfaces at their most unfavorable position for safe launch were investigated. Launch aircraft true airspeeds of 160, 200, and 235 knots, and altitude variations of 5000, 10,000, and 15,000 feet at a nominal airspeed of 200 knots showed favorable target separation characteristics. Autopilot malfunction with engine off case showed a satisfactory stable target separation from the launch aircraft. The alternate case of autopilot malfunction with engine on showed a safe separation but the target was unstable. The malfunctioning autopilot case, consisting of elevators locked at maximum travel position limits, showed results of safe separation, but the target pitches up in an unstable manner. A marginal target separation flight condition was encountered when a launch condition of maximum target aileron displacements was used. This maximum aileron control condition produced large target roll angles, resulting in wing tip clearance from the aircraft pylon of only 3.5 feet. Releasing of the target under this adverse aileron control condition is not recommended.

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TABLE OF CONTENTS

	Page
SUMMARY	iii
LIST OF FIGURES	vii
LIST OF TABLES	xi
INTRODUCTION	1
SIMULATION ANALYSIS DESCRIPTION	1
GENERAL	1
TARGET GENERAL DESCRIPTION	2
TARGET CARRIAGE LOCATION	2
FREE STREAM AERODYNAMICS	2
ENGINE CHARACTERISTICS	2
AUTOPILOT CHARACTERISTICS	6
INSTALLED AIRLOADS	6
AIRCRAFT FLOW FIELD	6
SEPARATION ANALYSIS CONDITION	7
FLIGHT CONDITIONS AND CONFIGURATIONS	7
RESULTS	7
FLOW FIELD EFFECT	7
VELOCITY EFFECT	111
ALTITUDE EFFECT	111
AUTOPILOT PITCH COMMAND EFFECT	111
SIDESLIP ANGLE EFFECT	112
FLOW FIELD CORRECTION FACTORS	112
AUTOPILOT AND ENGINE FAILURE MODES EFFECT	112
CONCLUSIONS	113

Page

RECOMMENDATIONS 114

REFERENCES 114

LIST OF FIGURES

Figure No.		Page
1	MQM-74C General Arrangement	3
2	DC-130A With MQM-74C Targets on the Inboard and Outboard Pylons	5
3	MQM-74C Longitudinal Separation Trajectory.	9
4	MQM-74C Lateral Separation Trajectory	10
5	MQM-74C Yaw Time History.	11
6	MQM-74C Angle of Attack Time History.	12
7	MQM-74C Pitch Attitude and Elevator Deflection Time History	13
8	MQM-74C Roll Angle and Aileron Time History	14
9	MQM-74C Longitudinal Separation Trajectory.	15
10	MQM-74C Lateral Separation Trajectory	16
11	MQM-74C Yaw Time History.	17
12	MQM-74C Angle of Attack Time History.	18
13	MQM-74C Pitch Attitude and Elevator Deflection Time History	19
14	MQM-74C Roll Angle and Aileron Time History	20
15	MQM-74C Longitudinal Separation Trajectory.	21
16	MQM-74C Lateral Separation Trajectory	22
17	MQM-74C Yaw Time History.	23
18	MQM-74C Angle of Attack Time History.	24
19	MQM-74C Pitch Attitude and Elevator Deflection Time History	25
20	MQM-74C Roll Angle and Aileron Time History	26
21	MQM-74C Longitudinal Separation Trajectory.	27
22	MQM-74C Lateral Separation Trajectory	28
23	MQM-74C Yaw Time History.	29

Figure No.		Page
24	MQM-74C Angle of Attack Time History.	30
25	MQM-74C Pitch Attitude and Elevator Deflection Time History .	31
26	MQM-74C Roll Angle and Aileron Time History	32
27	MQM-74C Longitudinal Separation Trajectory.	33
28	MQM-74C Lateral Separation Trajectory	34
29	MQM-74C Yaw Time History.	35
30	MQM-74C Angle of Attack Time History.	36
31	MQM-74C Pitch Attitude and Elevator Deflection Time History .	37
32	MQM-74C Roll Angle and Aileron Time History	38
33	MQM-74C Longitudinal Separation Trajectory.	39
34	MQM-74C Lateral Separation Trajectory	40
35	MQM-74C Yaw Time History.	41
36	MQM-74C Angle of Attack Time History.	42
37	MQM-74C Pitch Attitude and Elevator Deflection Time History .	43
38	MQM-74C Roll Angle and Aileron Time History	44
39	MQM-74C Pitch Rate Time History	45
40	MQM-74C Pitch Rate Time History	46
41	MQM-74C Pitch Rate Time History	47
42	Flight Path Angle vs. Time.	48
43	Flight Path Angle vs. Time.	49
44	Flight Path Angle vs. Time.	50
45	MQM-74C Longitudinal Separation Trajectory.	51
46	MQM-74C Lateral Separation Trajectory	52
47	MQM-74C Yaw Time History.	53
48	MQM-74C Angle of Attack Time History.	54

Figure No.		Page
49	MQM-74C Pitch Attitude and Elevator Deflection Time History .	55
50	MQM-74C Roll Angle and Aileron Time History	56
51	MQM-74C Longitudinal Separation Trajectory.	57
52	MQM-74C Lateral Separation Trajectory	58
53	MQM-74C Yaw Time History.	59
54	MQM-74C Angle of Attack Time History.	60
55	MQM-74C Pitch Attitude and Elevator Deflection Time History .	61
56	MQM-74C Roll Angle and Aileron Time History	62
57	MQM-74C Longitudinal Separation Trajectory.	63
58	MQM-74C Lateral Separation Trajectory	64
59	MQM-74C Yaw Time History.	65
60	MQM-74C Angle of Attack Time History.	66
61	MQM-74C Pitch Attitude and Elevator Deflection Time History .	67
62	MQM-74C Roll Angle and Aileron Time History	68
63	MQM-74C Longitudinal Separation Trajectory.	69
64	MQM-74C Lateral Separation Trajectory	70
65	MQM-74C Yaw Time History.	71
66	MQM-74C Angle of Attack Time History.	72
67	MQM-74C Pitch Attitude and Elevator Deflection Time History .	73
68	MQM-74C Roll Angle and Aileron Time History	74
69	MQM-74C Longitudinal Separation Trajectory.	75
70	MQM-74C Lateral Separation Trajectory	76
71	MQM-74C Yaw Time History.	77
72	MQM-74C Angle of Attack Time History.	78
73	MQM-74C Pitch Attitude and Elevator Deflection Time History .	79

Figure No.		Page
74	MQM-74C Roll Angle and Aileron Time History	80
75	MQM-74C Longitudinal Separation Trajectory.	81
76	MQM-74C Lateral Separation Trajectory	82
77	MQM-74C Yaw Time History.	83
78	MQM-74C Angle of Attack Time History.	84
79	MQM-74C Pitch Attitude and Elevator Deflection Time History .	85
80	MQM-74C Roll Angle and Aileron Time History	86
81	MQM-74C Longitudinal Separation Trajectory.	87
32	MQM-74C Lateral Separation Trajectory	88
83	MQM-74C Yaw Time History.	89
84	MQM-74C Angle of Attack Time History.	90
85	MQM-74C Pitch Attitude and Elevator Deflection Time History .	91
86	MQM-74C Roll Angle and Aileron Time History	92
87	MQM-74C Longitudinal Separation Trajectory.	93
88	MQM-74C Lateral Separation Trajectory	94
89	MQM-74C Yaw Time History.	95
90	MQM-74C Angle of Attack Time History.	96
91	MQM-74C Pitch Attitude and Elevator Deflection Time History .	97
92	MQM-74C Roll Angle and Aileron Time History	98
93	MQM-74C Longitudinal Separation Trajectory.	99
94	MQM-74C Lateral Separation Trajectory	100
95	MQM-74C Yaw Time History.	101
96	MQM-74C Angle of Attack Time History.	102
97	MQM-74C Pitch Attitude and Elevator Deflection Time History .	103
98	MQM-74C Roll Angle and Aileron Time History	104

Figure No.		Page
99	MQM-74C Longitudinal Separation Trajectory.	105
100	MQM-74C Lateral Separation Trajectory	106
101	MQM-74C Yaw Time History.	107
102	MQM-74C Angle of Attack Time History.	108
103	MQM-74C Pitch Attitude and Elevator Deflection Time History . .	109
104	MQM-74C Roll Angle and Aileron Time History	110

L I S T O F T A B L E S

Table No.		Page
I	Target Dimensional, Weight, and Fixed Installed Conditions . .	4
II	MQM-74C Simulation Separation Study Digital Run Schedule . . .	8

INTRODUCTION

This report presents an analysis of the air launch separation characteristics of the MQM-74C powered aerial target when released from a DC-130A launch aircraft in straight and level flight. The MQM-74C is an uprated version of the MQM-74A and is currently a ground-launched target.

The effects of variations in launch aircraft flight conditions similarly used for releasing other targets, for example the BQM-34 type aerial vehicles, as well as possible target malfunctions, on the air launch separation characteristics were investigated.

This study was conducted under the authority of reference (a).

The analysis was performed using a digital computer program to solve the six-degree-of-freedom equations for the target moving relative to the aircraft. The following inputs were required for the analysis:

1. Target carriage location relative to the aircraft
2. Target mass and inertia properties
3. Target launch aspects
4. Target autopilot and engine characteristics
5. Installed airloads
6. Free stream aerodynamic characteristics of the target
7. Aircraft interference flow field
8. Launch aircraft flight conditions at time of release.

The above items are treated in the following discussion. The selection of aircraft flight conditions for the analysis is discussed also. Each flight condition is defined by true velocity, altitude, launch aircraft angle of attack, and captive airloads on the target. The effect of varying each parameter is considered in the analysis.

The air release and launch trajectories of the MQM-74C target are summarized in this report, with emphasis placed on target separation distance and target dynamics. Analyses of position and angular rates are used to establish whether the target drone actually does clear all DC-130A structure components safely and rapidly.

SIMULATION ANALYSIS DESCRIPTION

GENERAL

Air launch characteristics were investigated using a CDC-6600 digital computer and a generalized six-degree-of-freedom simulation program. The digital

program was structured to handle the MQM-74C target. The MQM-74C physical dimensions, free stream aerodynamics, autopilot and control logic, engine performance characteristics including gyroscopic effects, and installed airloads were introduced into the digital program. Verification of the airframe dynamics was performed by comparing the Northrop analog simulation of reference (b) with the NAVAIRDEVCEN (Naval Air Development Center) digital simulation. The flight conditions of case 8 in reference (b) were used to compare with the NAVAIRDEVCEN simulation (autopilot on and engine off). Only the short period frequency was of interest, since the target separation is completed in approximately 2 seconds. The short period frequency and damping ratio from reference (b) is 0.542 cycles/sec and 0.183, respectively, and compared favorably to NAVAIRDEVCEN results of 0.56 and 0.19, respectively.

TARGET GENERAL DESCRIPTION

The general arrangement of the MQM-74C target is given in figure 1. The target drone is a conventionally designed aircraft with a high wing of moderate aspect ratio and inverted Y empennage. Control is accomplished by actuating the elevators and ailerons. The nominal mass properties and other pertinent data used in the analysis are in accordance with reference (c) and are presented in Table I.

TARGET CARRIAGE LOCATION

The MQM-74C target is suspended on launch pylons under the wings of the DC-130A aircraft at four locations as shown in figure 2. The targets are installed -3.0 degrees (nose down) with respect to the DC-130A fuselage reference line from all carriage stations and are parallel with the launch aircraft. The target mounted on the inboard pylon of the right wing is used in the analysis and is considered to be representative of the counterpart on the left side of the aircraft due to the symmetry of the configuration. The analysis is limited to the inboard pylon target mounting because experience has shown this location to be more critical for air launching.

FREE STREAM AERODYNAMICS

The target drone free stream aerodynamic data used in the analysis were obtained from reference (b). The data are referenced to the target wing area of 8 ft^2, target mean aerodynamic chord of 1.04 ft, and span of 5.66 ft. Moments are referenced to the 1/4 chord of the wing which corresponds to 0.935 ft aft of the target's center of gravity at full weight. The data in the longitudinal axis are in the stability axes and in the lateral axes are in the body axes, as provided by reference (b). The axes system and elevator and aileron deflections used in the analyses are defined in reference (b).

ENGINE CHARACTERISTICS

The WR24-7 is a target drone turbojet engine. It is housed in the aft fuselage with the air intake duct on the underside of the fuselage. The engine is mounted so that the thrust line is 0.4 inch above the horizontal reference line of the target providing a pitch-down moment. Reference (c)

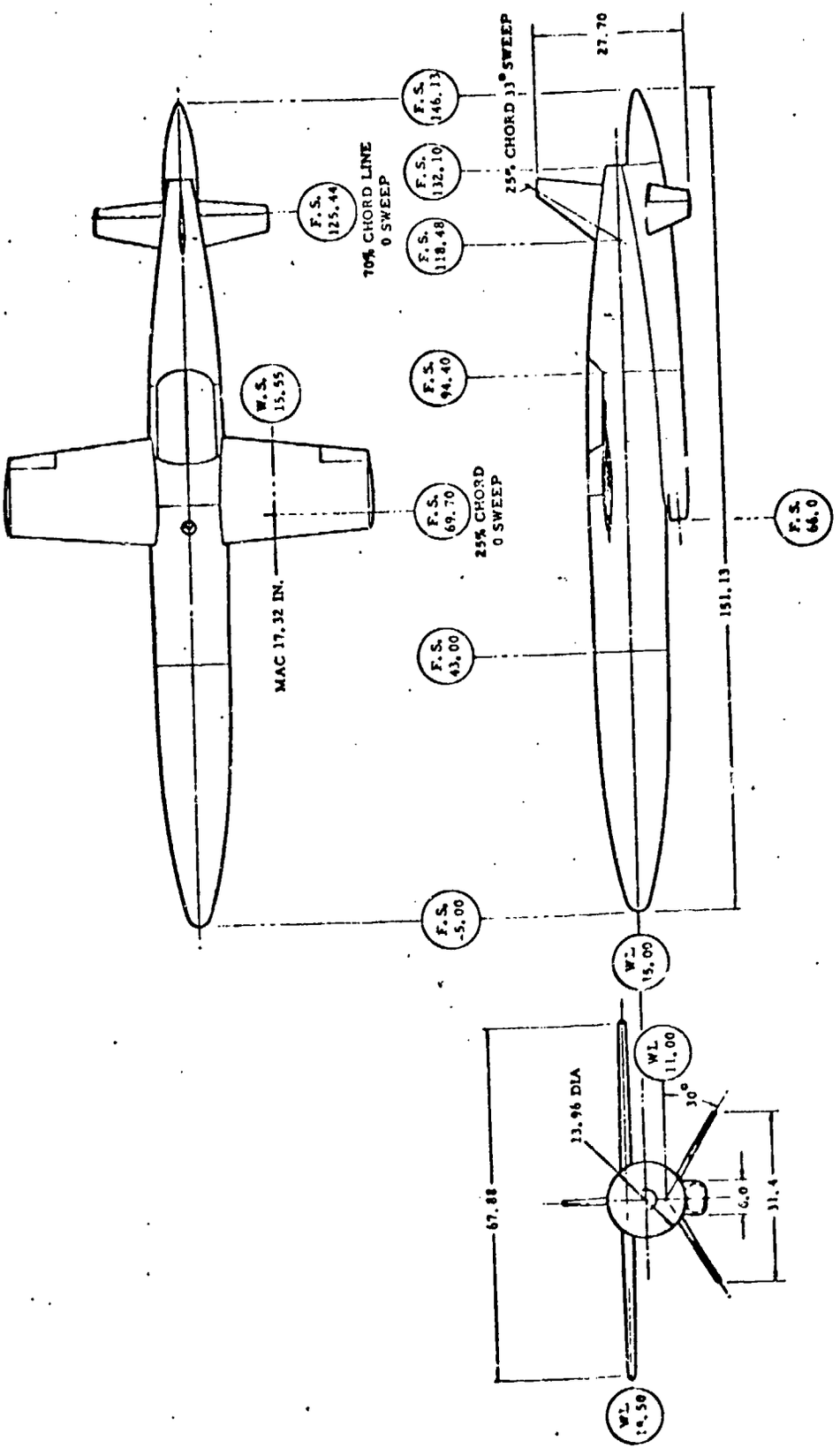

Figure 1. MQM-74C General Arrangement

TABLE I
TARGET DIMENSIONAL, WEIGHT, AND
FIXED INSTALLED CONDITIONS

TARGET PHYSICAL CHARACTERISTICS

Gross Weight = 414 lbs
Moment Reference Center of Gravity = 2.89 in. forward of the 1/4 chord of the wing
Moment of Inertia about X Axis = 3.7 slug-ft^2
Moment of Inertia about Y Axis = 79.4 slug-ft^2
Moment of Inertia about Z Axis = 81.2 slug-ft^2
Reference Area = 8 ft^2 (Wing Area)
Reference Length for Pitching and Yawing Moment = 1.44 ft (wing chord)
Reference Length for Rolling Moment = 5.66 ft (wing span)
Nose Location = 74.7 in. forward of C.G.
Tail Location = 151.1 in. aft of nose

AERODYNAMIC DATA

Axis System Definition - Reference (b)

SUSTAINER ENGINE DATA

Reference (c)

TARGET INSTALLED POSITION

Pitch attitude with respect to A/C Fuselage Reference Line = -3 deg
Target C.G. Position with Respect to A/C C.G.
520 in. fuselage station
310 in. right wing station
197 in. water line station

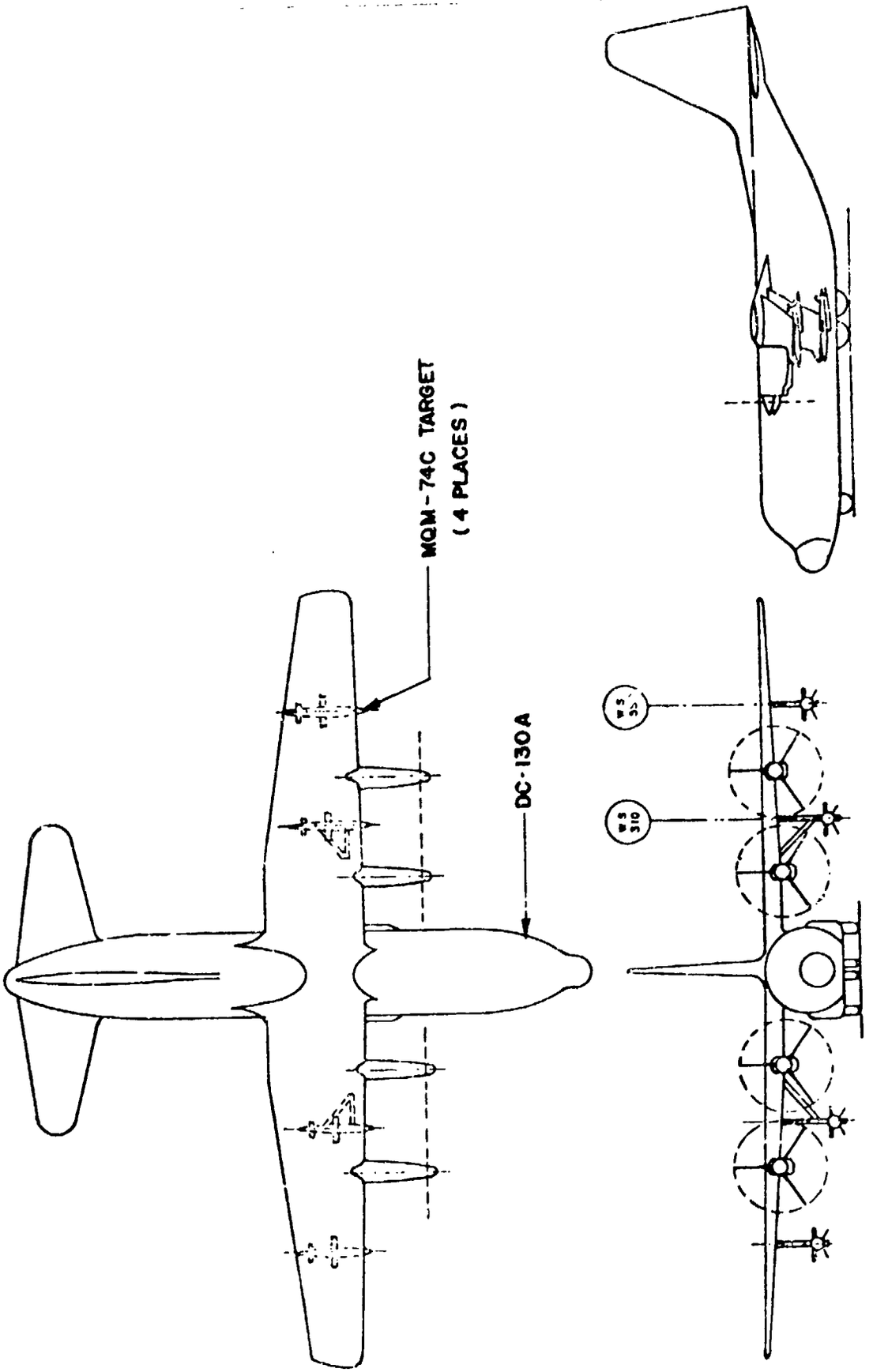

Figure 2. DC-130A With MQM-74C Targets on the Inboard and Outboard Pylons

provided the engine performance data as a function of RPM and velocity. Since the engine will be at full thrust at 60,900 RPM, at launch, the data used are for the noted RPM condition. The engine provides a gyroscopic moment which is included in the torques and is

$$I_{\omega} = 0.00208 \times 2\pi \times RPM/60$$

$$= 13.27 \text{ ft/lbs sec, at launch}$$

The engine has positive rotation about the longitudinal axis.

AUTOPILOT CHARACTERISTICS

The MQM-74C autopilot has a two-axis flight control system. Pitch and roll attitudes, sensed by a vertical gyro, are fed through a servo amplifier to the elevators and ailerons, respectively, to achieve a closed loop control system. The elevator and aileron actuators are simulated with a 0.05-second lag. Reference (b) provided the information needed to simulate the autopilot. Elevator deflections are limited to ±12 degrees and aileron deflections are limited to ±24 degrees.

INSTALLED AIRLOADS

The magnitude and direction of the MQM-74C installed airloads are an input required for the separation analysis. The installed airloads were determined analytically for a number of DC-130A flight conditions within its flight envelope. Reference (d) provided this information.

AIRCRAFT FLOW FIELD

A certain amount of knowledge about the aircraft flow field is required to properly simulate the transition of the target from the carriage position to the point where it is no longer influenced by the presence of the aircraft. The flow field beneath the DC-130A aircraft is determined from unpublished wind tunnel data and analytical techniques.

The wind tunnel data provided downwash and sidewash as a function of DC-130A angle of attack, wing station, and water line for one fuselage station. The test data extended to the right wing station of 580 inches and water line 255 inches below the aircraft center of gravity. In order to complete the flow field data for various fuselage stations, it was necessary to use analytical estimation methods. References (e) and (f) provided downwash angle trends forward and aft for a few representative wings. Using the established trends and correcting the analytical data with respect to the wind tunnel data, downwash angles for various fuselage stations along the wing station and water line were determined. Since no analytical techniques were available to establish sidewash angles for various fuselage stations, it was decided to linearily decay to zero this angle with respect to fuselage location. This assumption is considered to be adequate as other separation studies have shown this parameter to have little or no effect on the target separation from the aircraft.

SEPARATION ANALYSIS CONDITIONS

The analysis was performed with the launch aircraft maintaining level flight and constant speed. An aircraft gross weight of 110,000 pounds with a center of gravity at 24 percent MAC was used as a typical flight condition. Table II provides a listing of the conditions analyzed.

Flight Conditions and Configurations

Systematic velocity variation at constant altitudes and altitude variations at constant velocity were performed to determine critical velocity-altitude regions for release. These altitudes and velocities were within the DC-130A flight envelope. Flow field effects including correction factors of +2.0 degrees were examined to ascertain the effect of the downwash analytical estimates on the target separation characteristics. Autopilot and engine failure in combination were investigated. Target launching as the aircraft sideslipped at 5 degrees was examined to determine if contact in the lateral plane was possible.

R E S U L T S

The target trajectories resulting from the previously described analysis including time histories of lateral plane motion, angle of attack, heading angle, pitch attitude, control surface deflections, roll angle, and for some cases pitch rate and flight path angle are shown in figures 3 through 104 to substantiate the conclusions made. These figures are automatic Calcomp machine plots to facilitate data acquisition and reduction from the extensive digital printout. The longitudinal separation trajectories were represented by the target nose, center of gravity, and tail locations with a line connecting these points. Locating the target dimensions in this manner helps to better visualize graphically the separation process.

The digital simulation ran for 3 seconds for most launch conditions analyzed. This time span allows for adequate target separation distance to be developed so that the flow field is cleared and vehicle instabilities are taken into account. In cases where the target instability exceeded available digital input data, decreased simulation time was used but of sufficient length to determine separation characteristics.

Most digital simulation cases noted in Table II were conducted with the DC-130A flow field and autopilot and engine operating. With the exception of those cases that are noted in the remarks section of the table, these conditions always exist.

FLOW FIELD EFFECT

Figures 3 through 14 show the effect of the aircraft flow field on the target separating from the DC-130A. Very little difference is found in the target trajectory due to the flow field. At the end of 3 seconds of the trajectory, figures 3 and 9 indicate an increased 2-foot drop with the flow field on. The increase in separation distance is attributable to the downward installed normal force coefficient (See Table II for cases 1 and 2 with and without flow field, respectively). Even though the target pitch attitude

TABLE II
MQM-74C SIMULATION SEPARATION STUDY
DIGITAL RUN SCHEDULE

CASE	V_o K TAS	Alt Feet	θ_c Deg	A/C α Deg	TARGET INSTALLED AERODYNAMIC COEFF $C_{N_{INST}}$	$C_{A_{INST}}$	$C_{Y_{INST}}$	$C_{\ell_{INST}}$	$C_{m_{INST}}$	$C_{n_{INST}}$	REMARKS
1	200	10000	-5.	4.95	-	-	-	-	-	-	Flow field off. Autopilot and engine on.
2	200	"	-5.	4.95	-.091	.0225	.01	.0003	.057	-.001	DC130A flow field.
3	160	"	-5.	7.95	-.01	.024	.025	.0005	.055	-.002	" " "
4	235	"	-5.	2.15	-.159	.0187	.01	.0002	.058	-.001	" " "
5	200	5000	-5.	4.05	-.12	.021	.01	.0002	.058	-.001	" " "
6	↑	15000	-5.	5.85	-.06	.023	.015	.0005	.056	-.002	" " "
7		10000	0.	4.95	-.091	.0225	.01	.0003	.057	-.001	" " "
8		↑	-8.	↑	-.091	.0225	↑	↑	.057	↑	
9			-5.		-.23	.0145			.058		C130 flow field correction factor, 2 deg (downwash).
10			-5.		.05	.024			.058		C130 flow field correction factor, 2 deg (upwash).
11			-		.0907	.023			.057		C130A flow field elevator deflection = -12 deg (trailing edge up).
12			-								Autopilot and engine off.
13			-								Autopilot off and engine on.
14			-								Aileron deflection = 24 deg (clockwise roll).
15			-								Aileron deflection = -24 deg (counter clockwise roll).
16	200	10000	-5.	4.95	.0907	.023	.01	.0003	.057	-.001	Launch A/C sideslip angle = 5 deg and autopilot on.

where:

V_o - Launch A/C Airspeed
Alt - Launch A/C Altitude
θ_c - Pitch Attitude Command to Target
A/Cα - Launch A/C Angle of Attack

Subscript INST - Installed

C_N - Normal Force Coefficient
C_A - Drag Coefficient
C_Y - Side Force Coefficient
C_ℓ - Rolling Moment Coefficient
C_m - Pitching Moment Coefficient
C_n - Yawing Moment Coefficient

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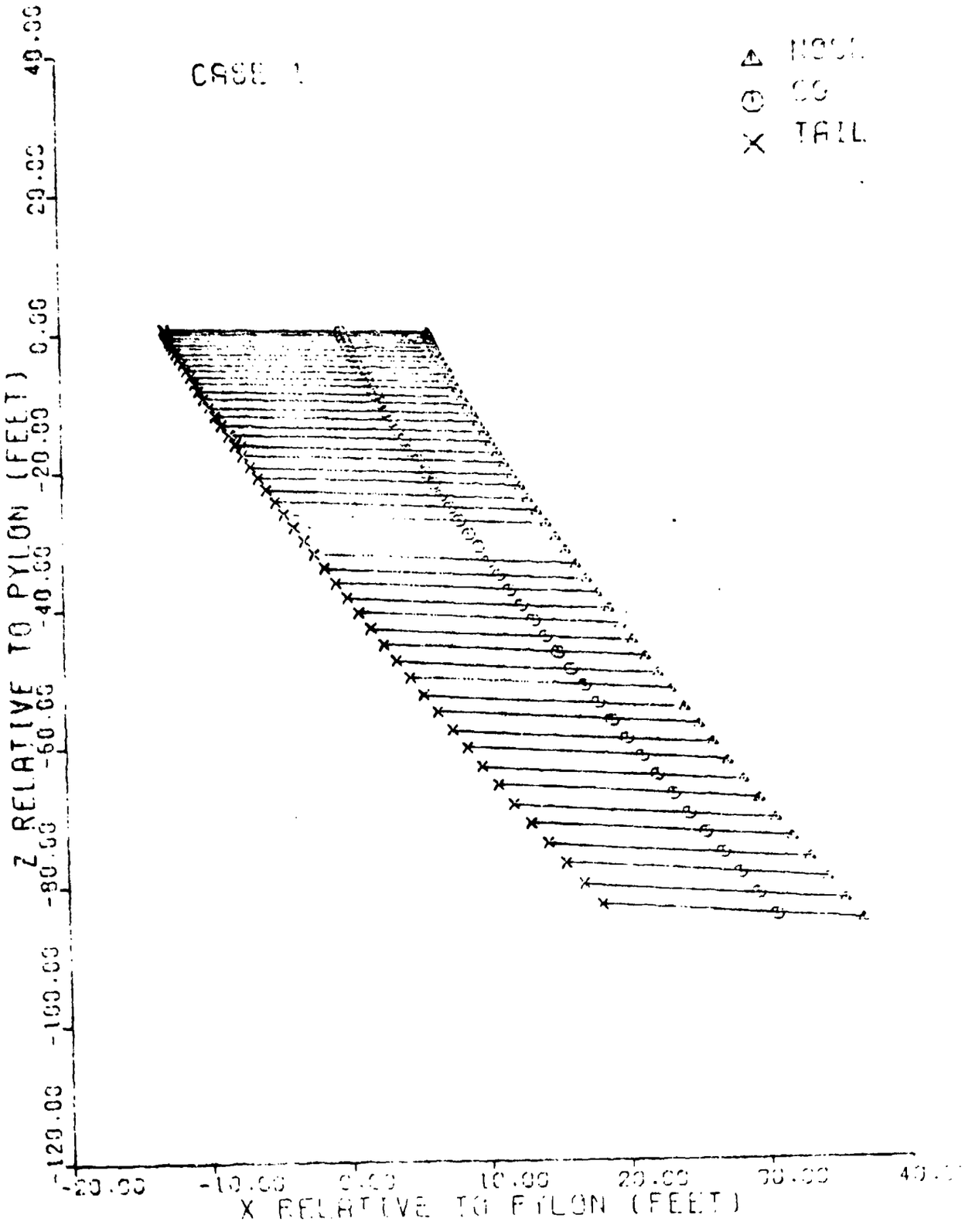

Figure 3. MQM-74C Longitudinal Separation Trajectory

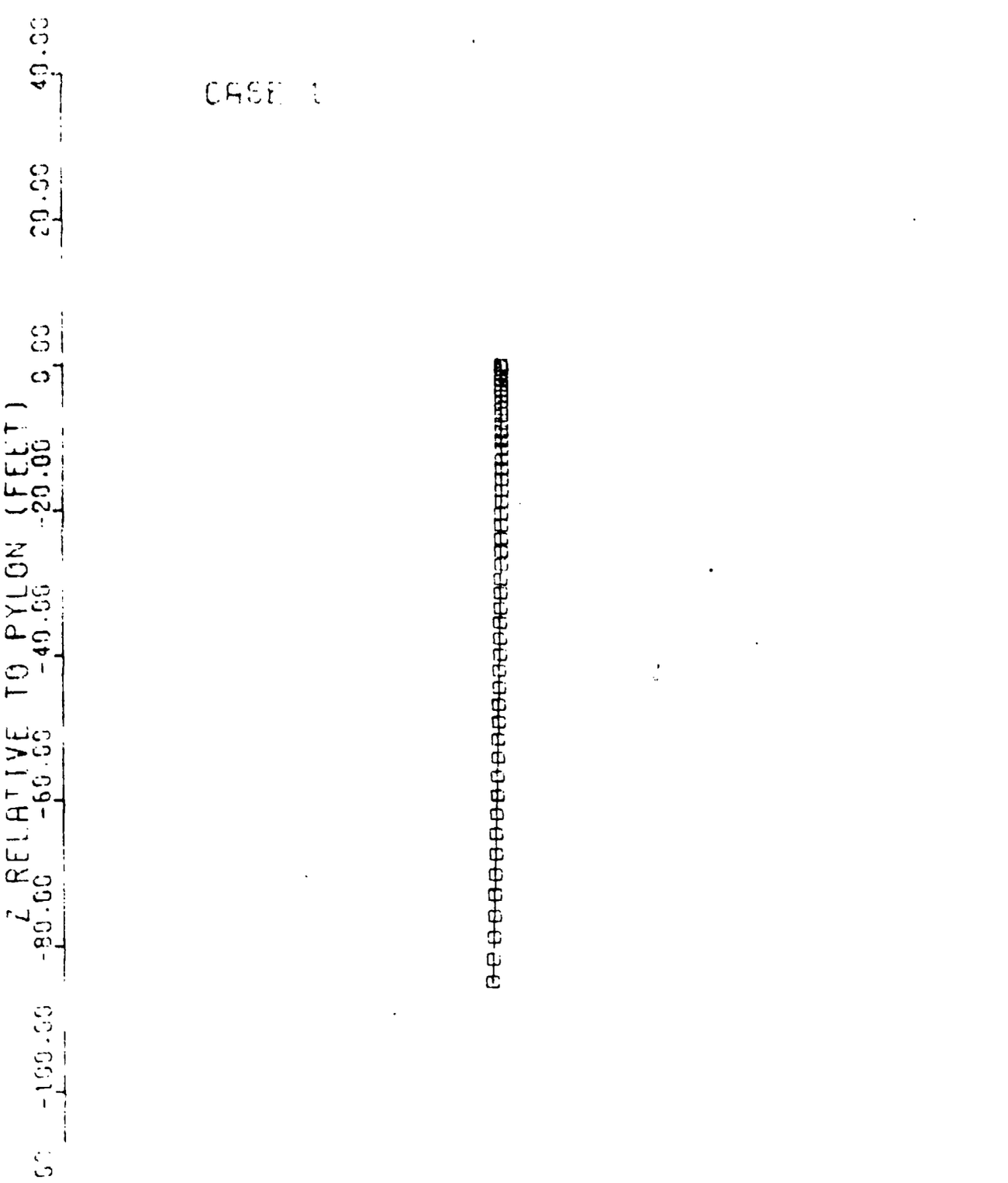

Figure 4. MQM-74C Lateral Separation Trajectory

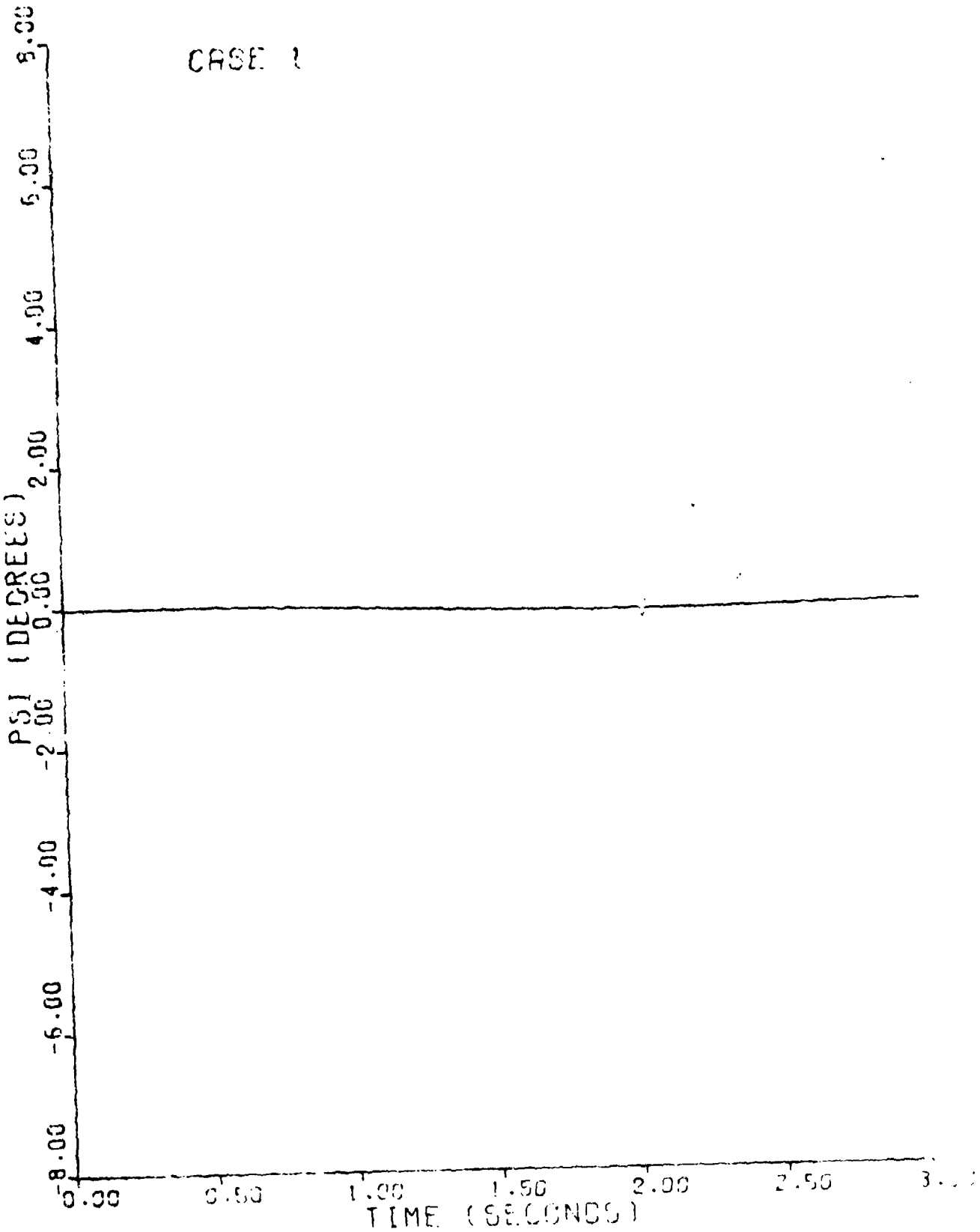

Figure 5. MQM-74C Yaw Time History

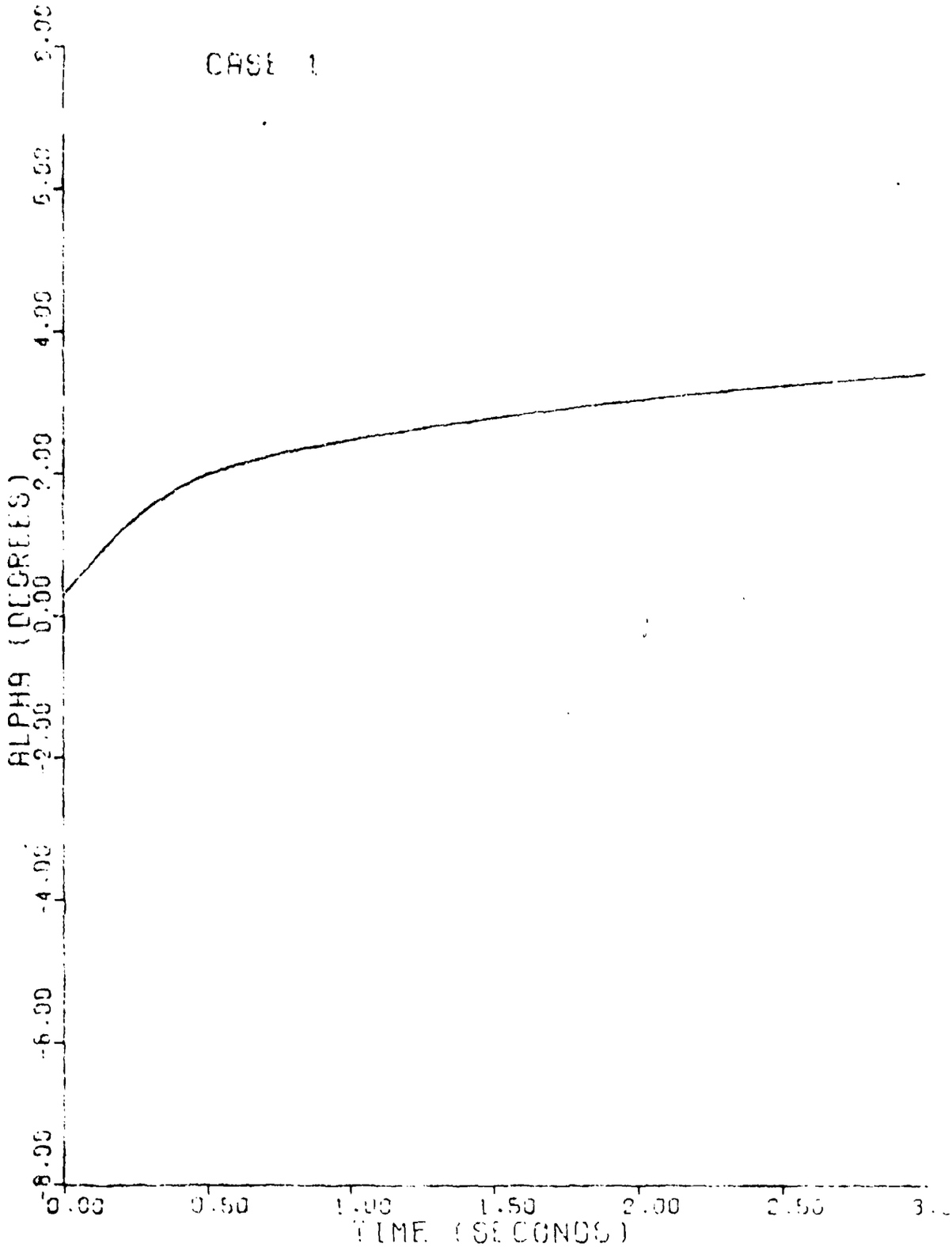

Figure 6. MQM-74C Angle of Attack Time History

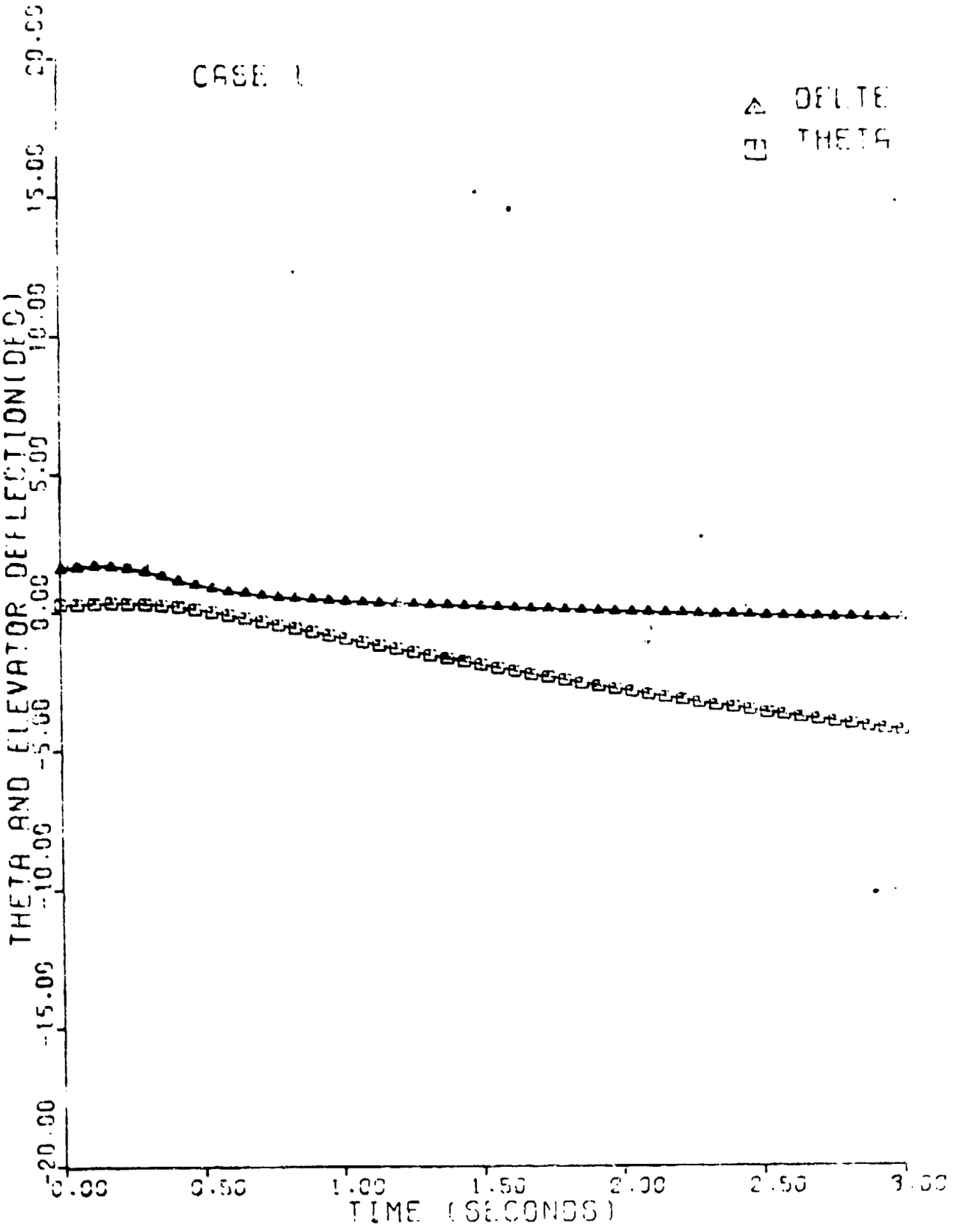

Figure 7. MQM-74C Pitch Attitude and Elevator Deflection Time History

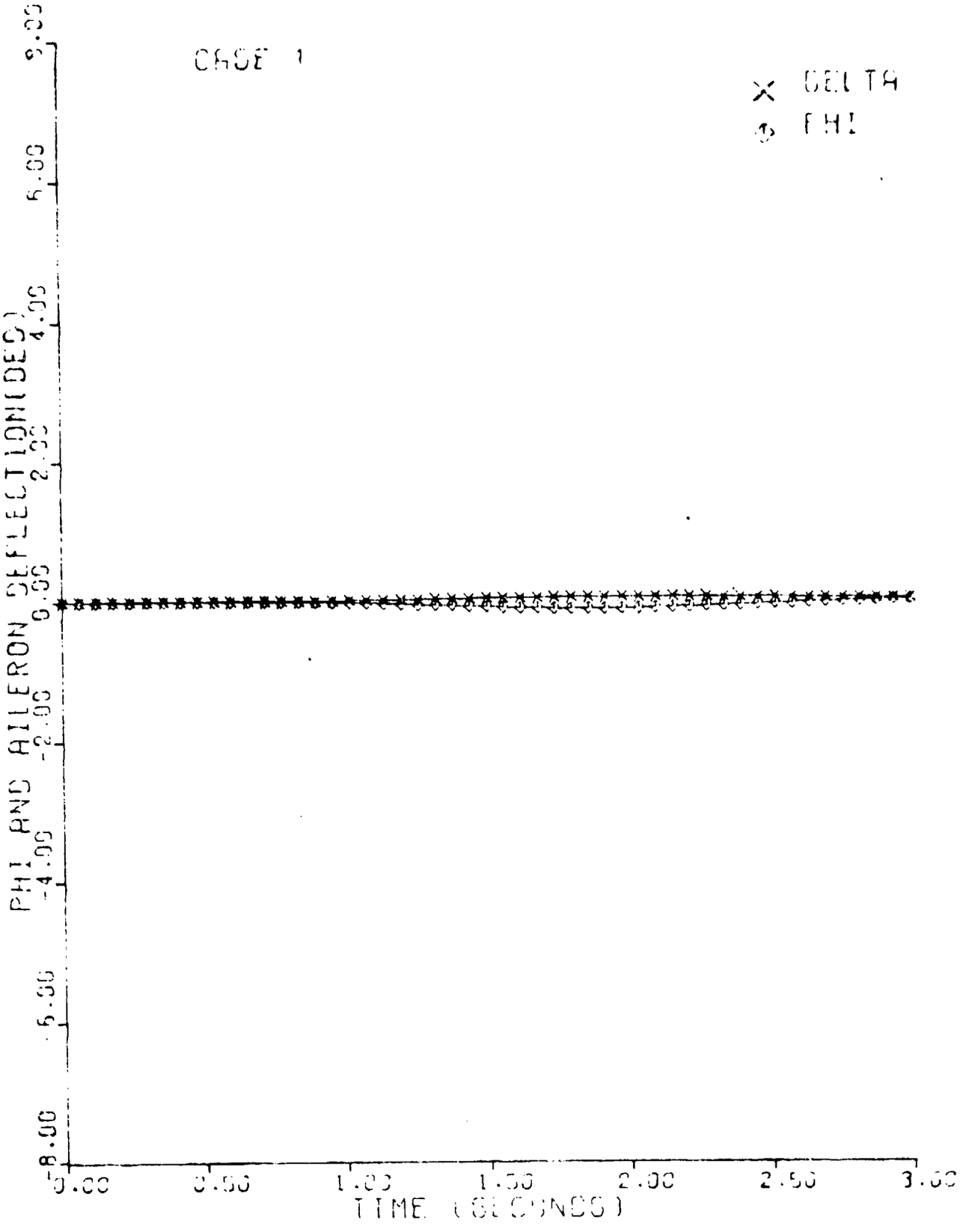

Figure 8. MQM-74C Roll Angle and Aileron Time History

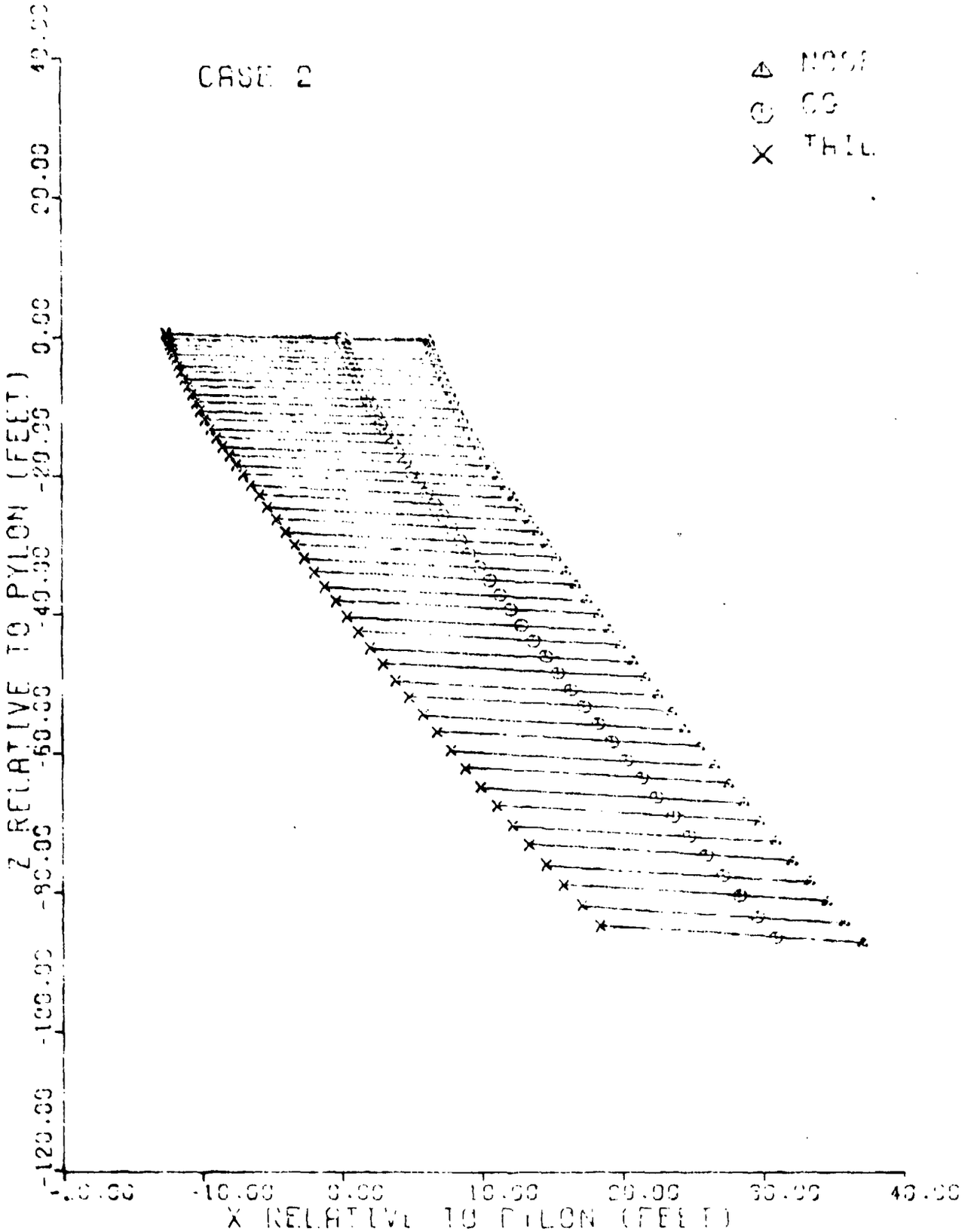

Figure 9. MQM-74C Longitudinal Separation Trajectory

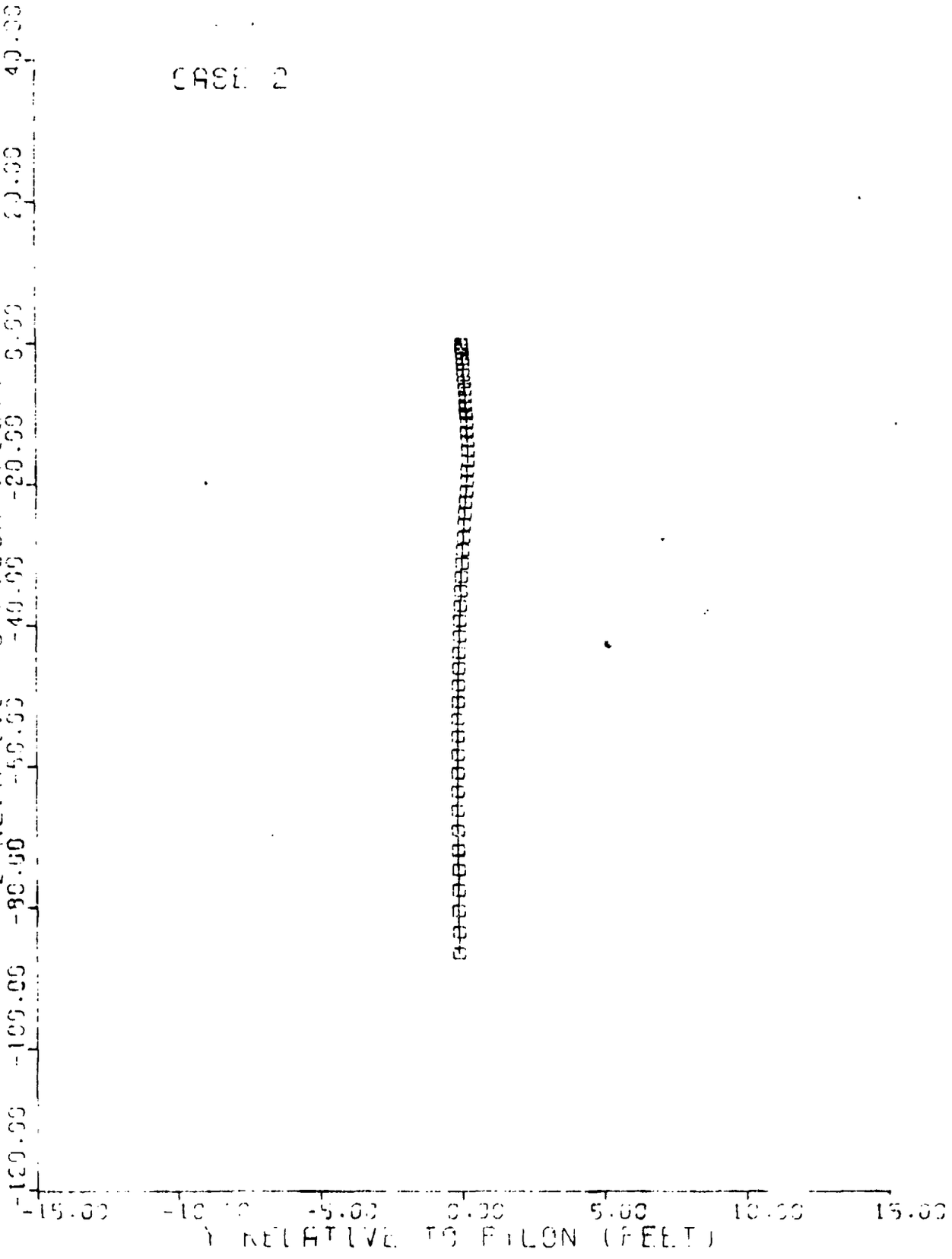

Figure 10. MQM-74C Lateral Separation Trajectory

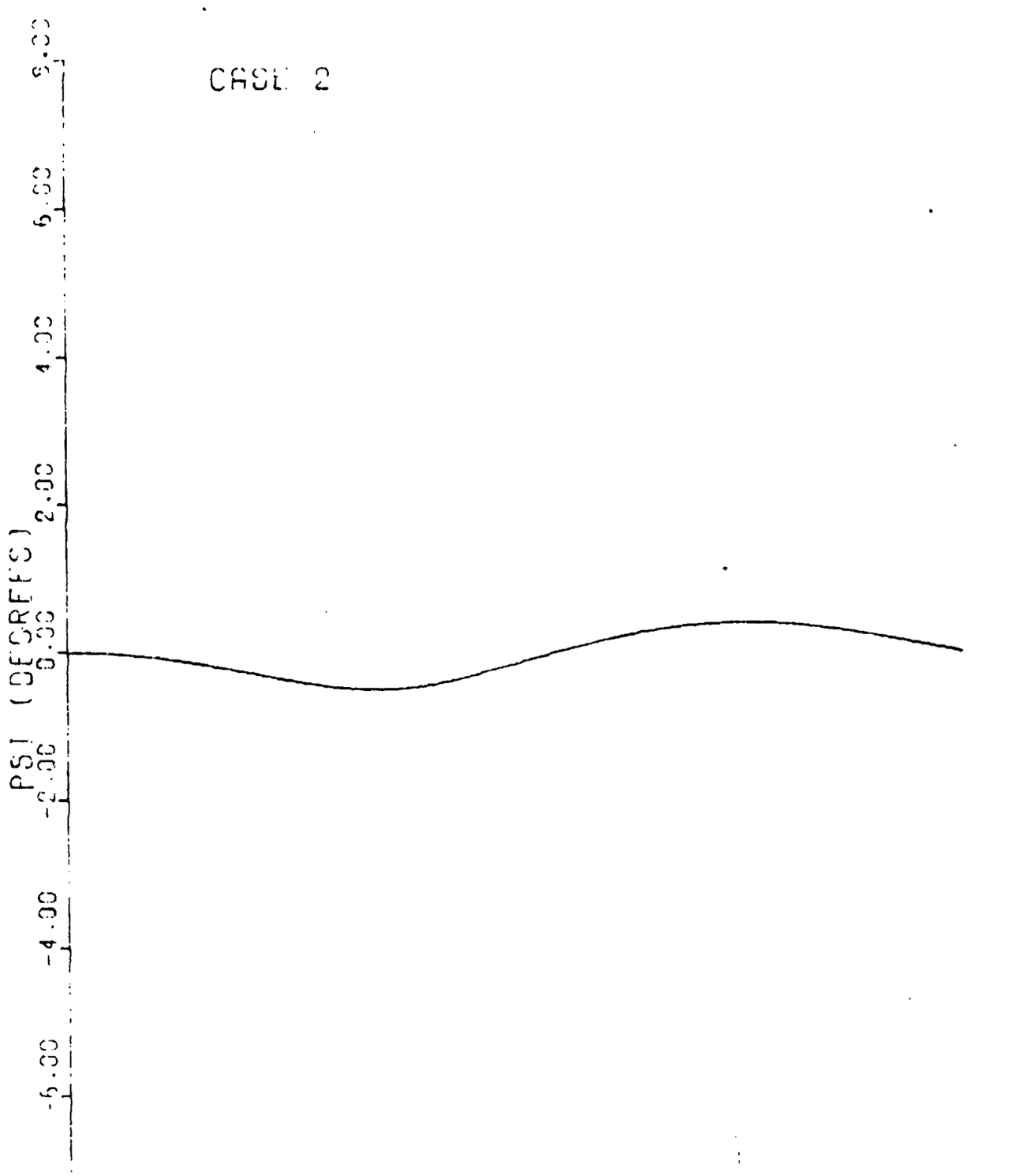

Figure 11. MQM-74C Yaw Time History

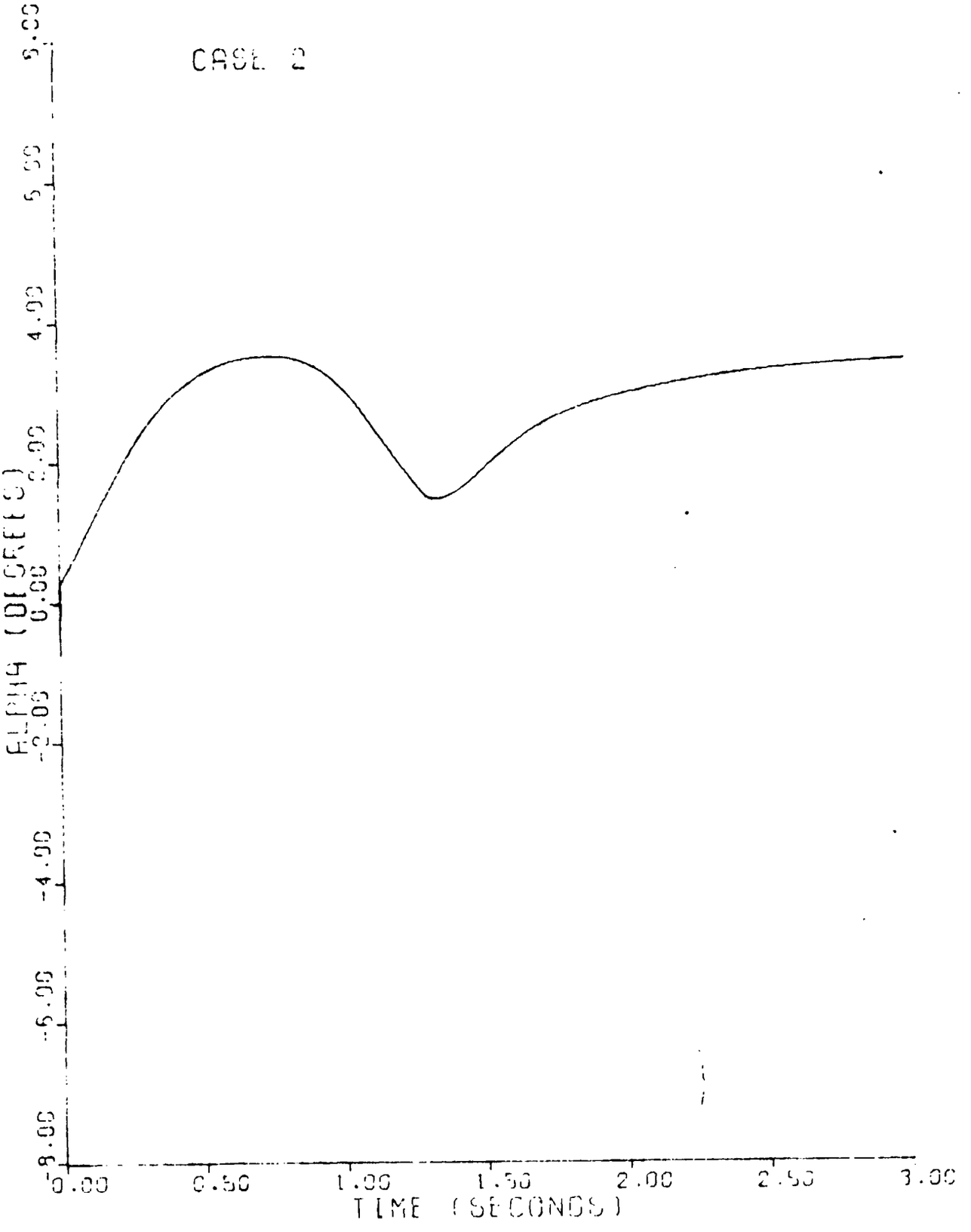

Figure 12. MQM-74C Angle of Attack Time History

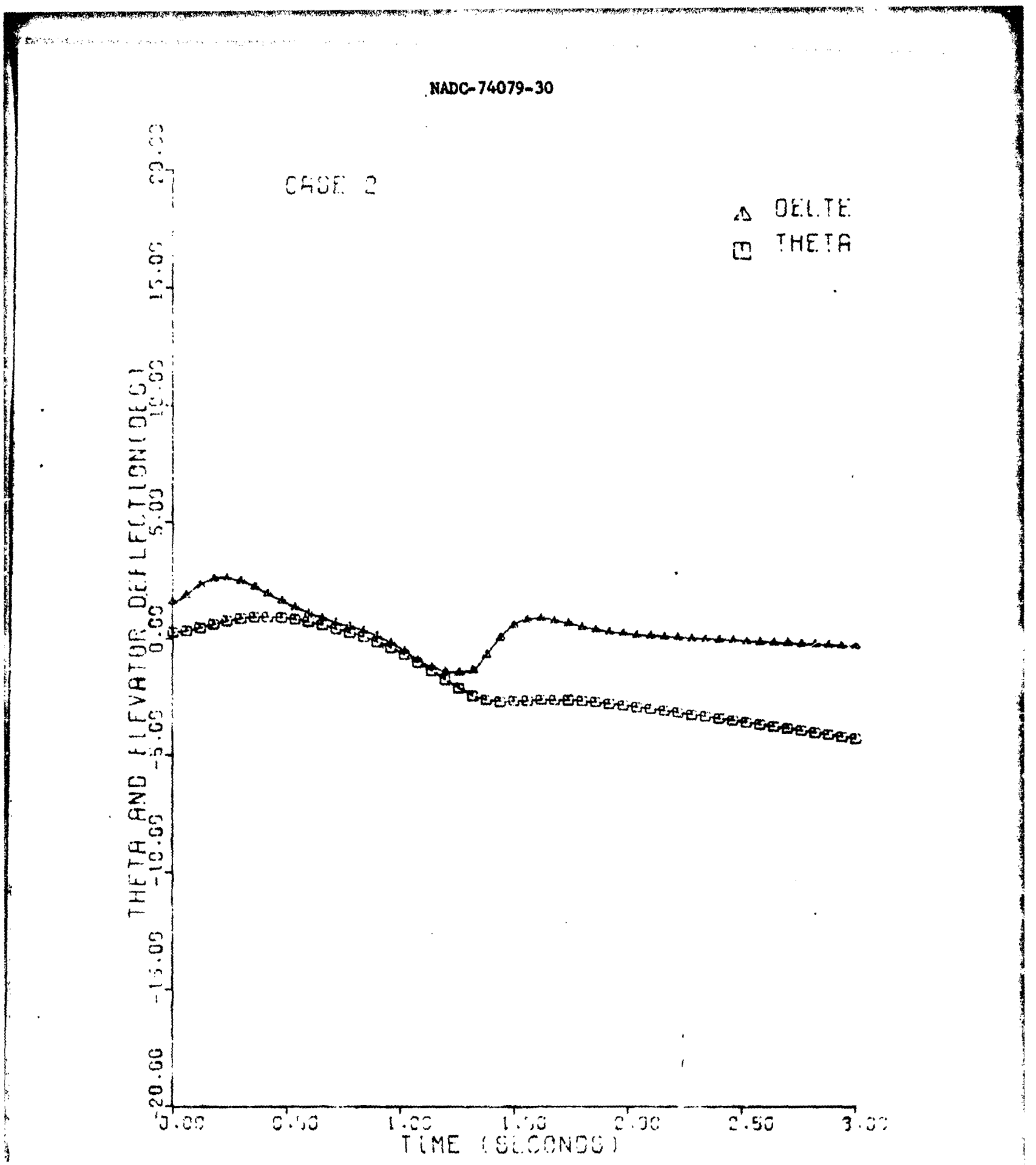

Figure 13. MQM-74C Pitch Attitude and Elevator Deflection Time History

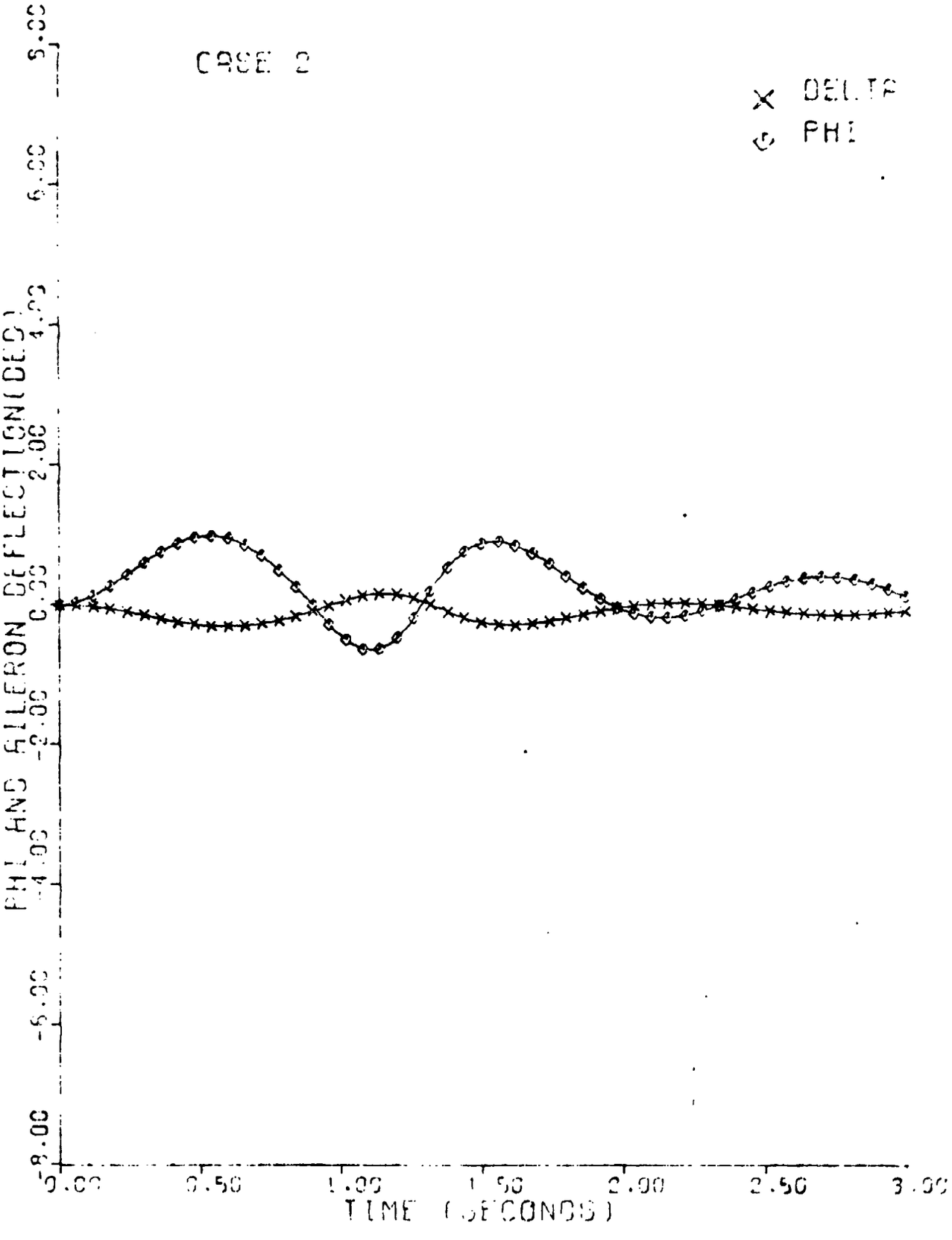

Figure 14. MQM-74C Roll Angle and Aileron Time History

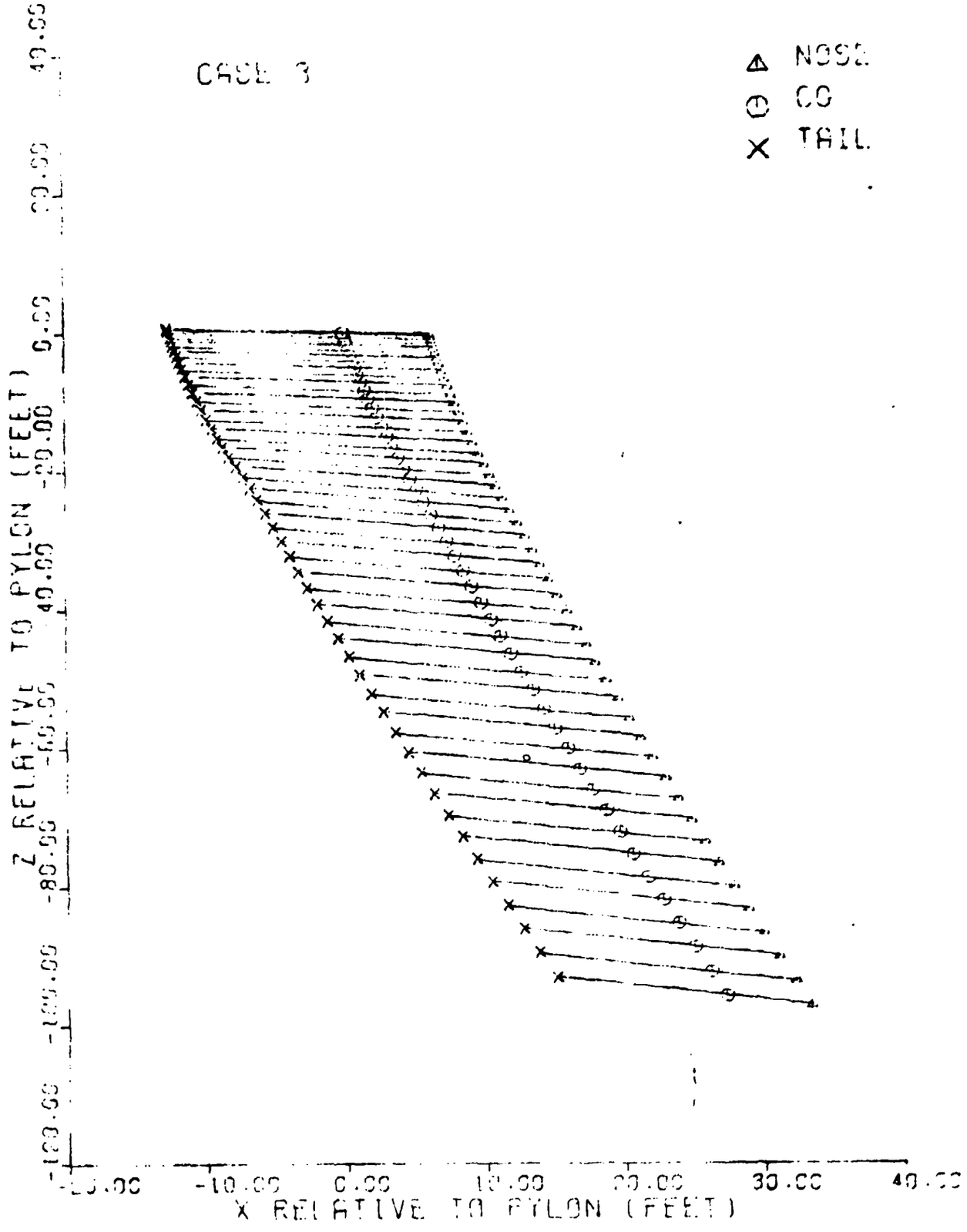

Figure 15. MQM-74C Longitudinal Separation Trajectory

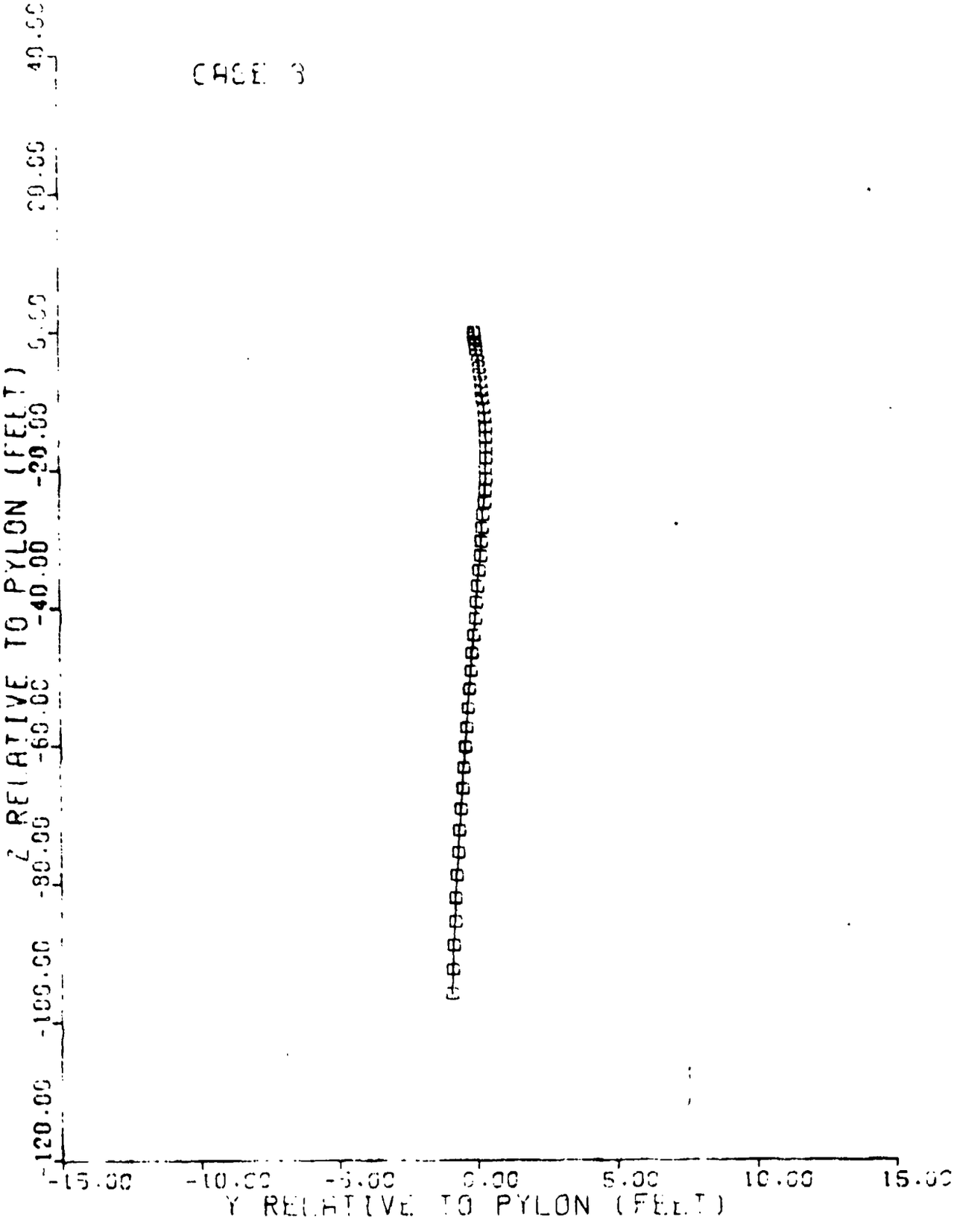

Figure 16. MQM-74C Lateral Separation Trajectory

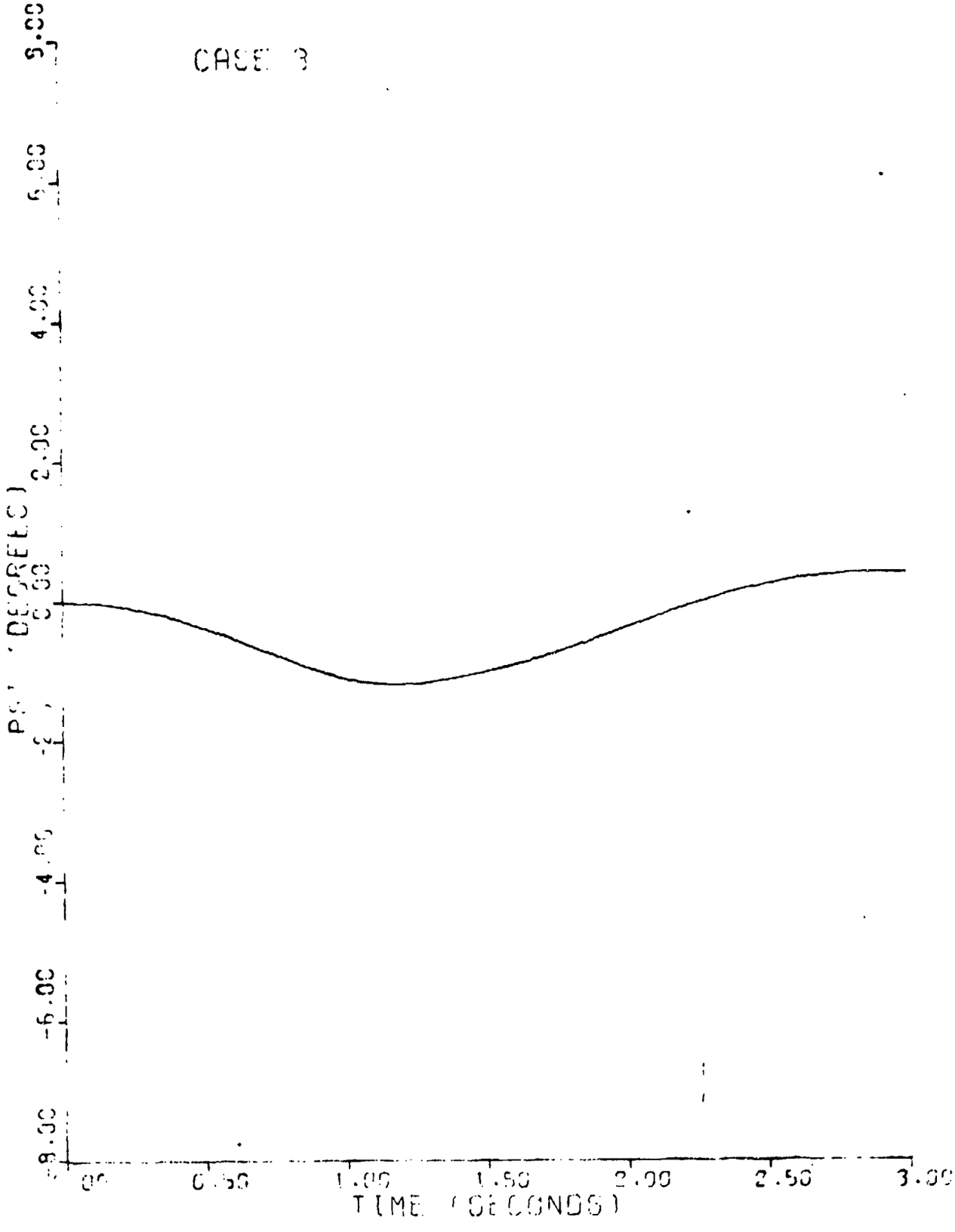

Figure 17. MQM-74C Yaw Time History

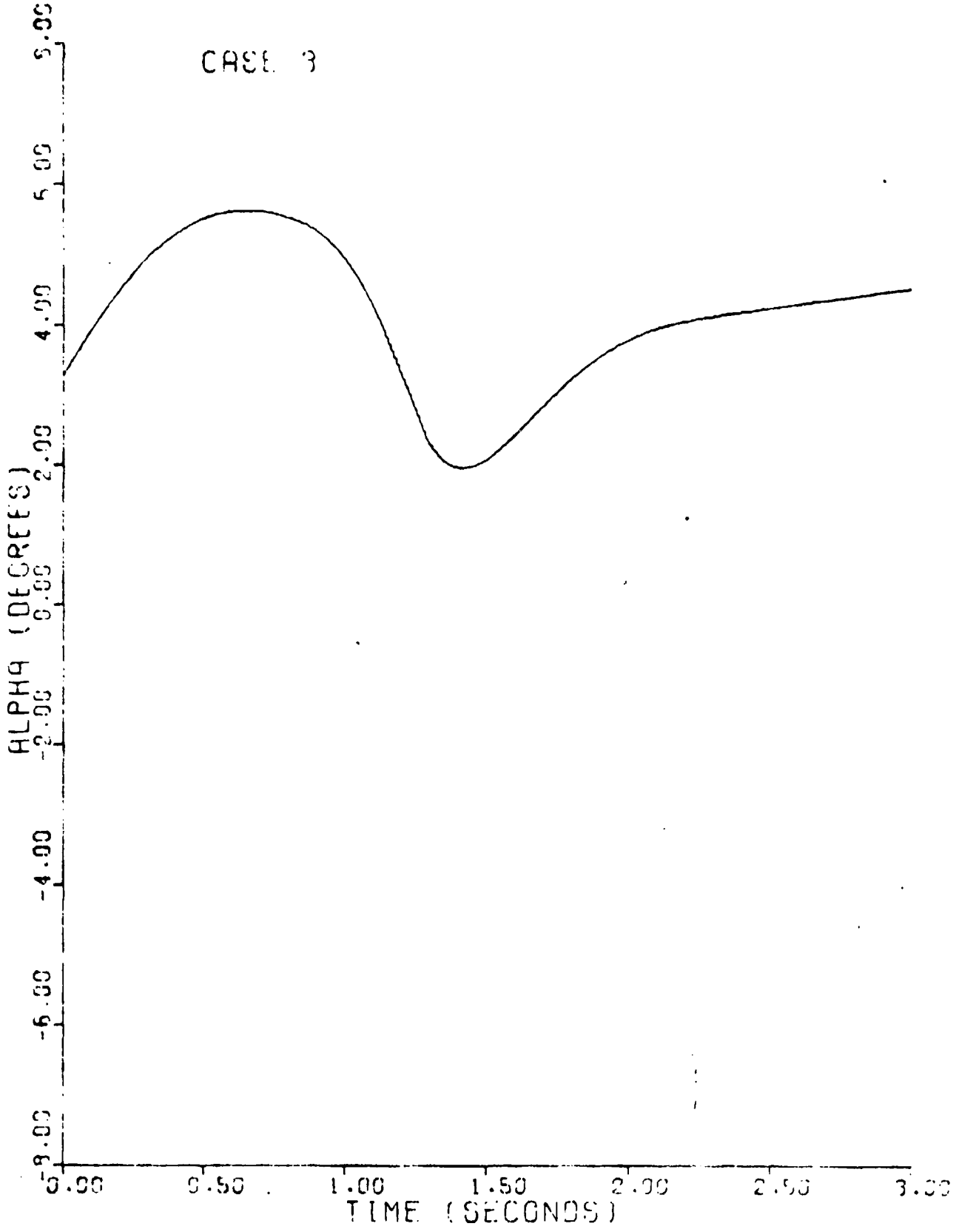

Figure 18. MQM-74C Angle of Attack Time History

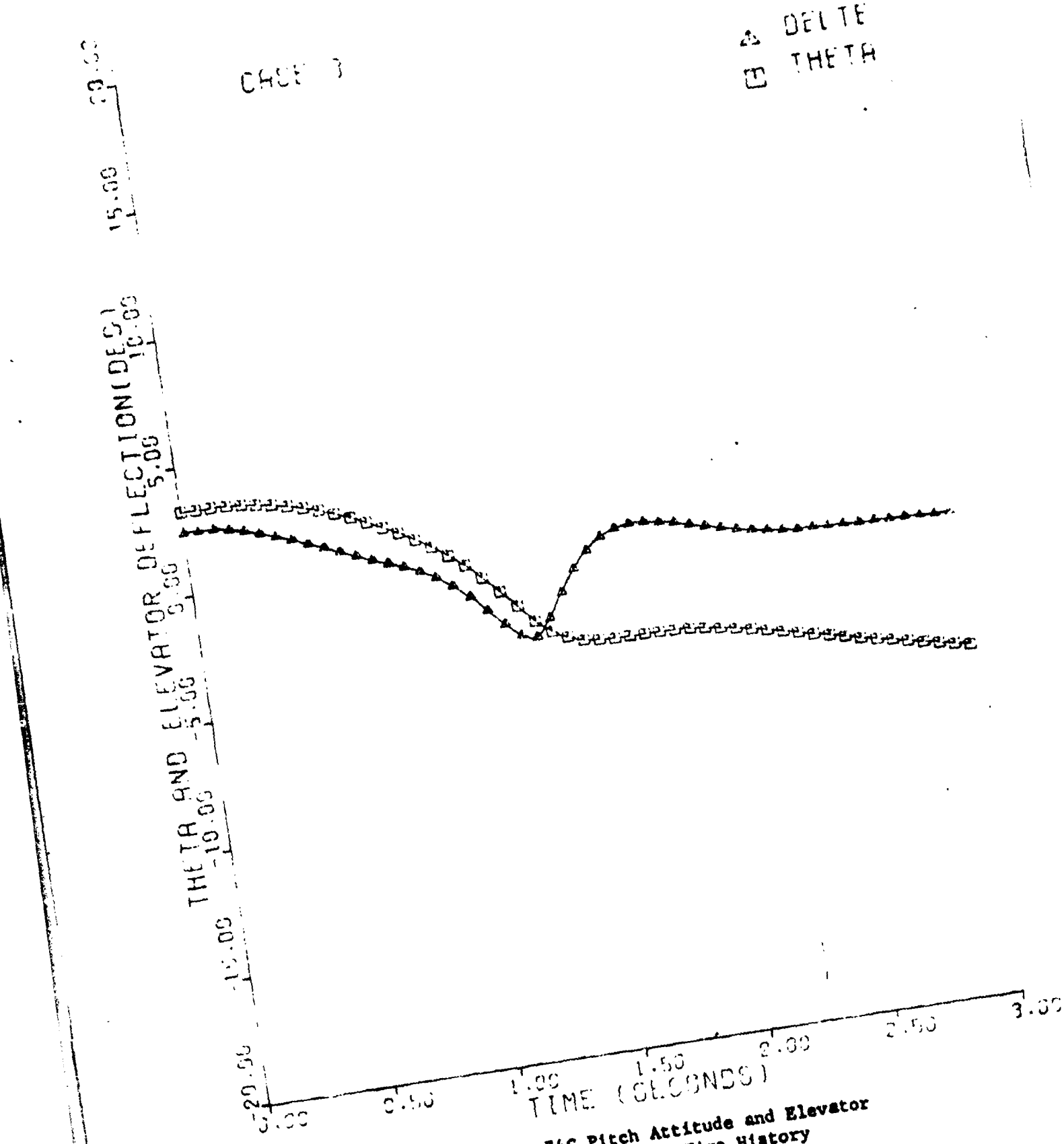

Figure 19. MQM-74C Pitch Attitude and Elevator Deflection Time History

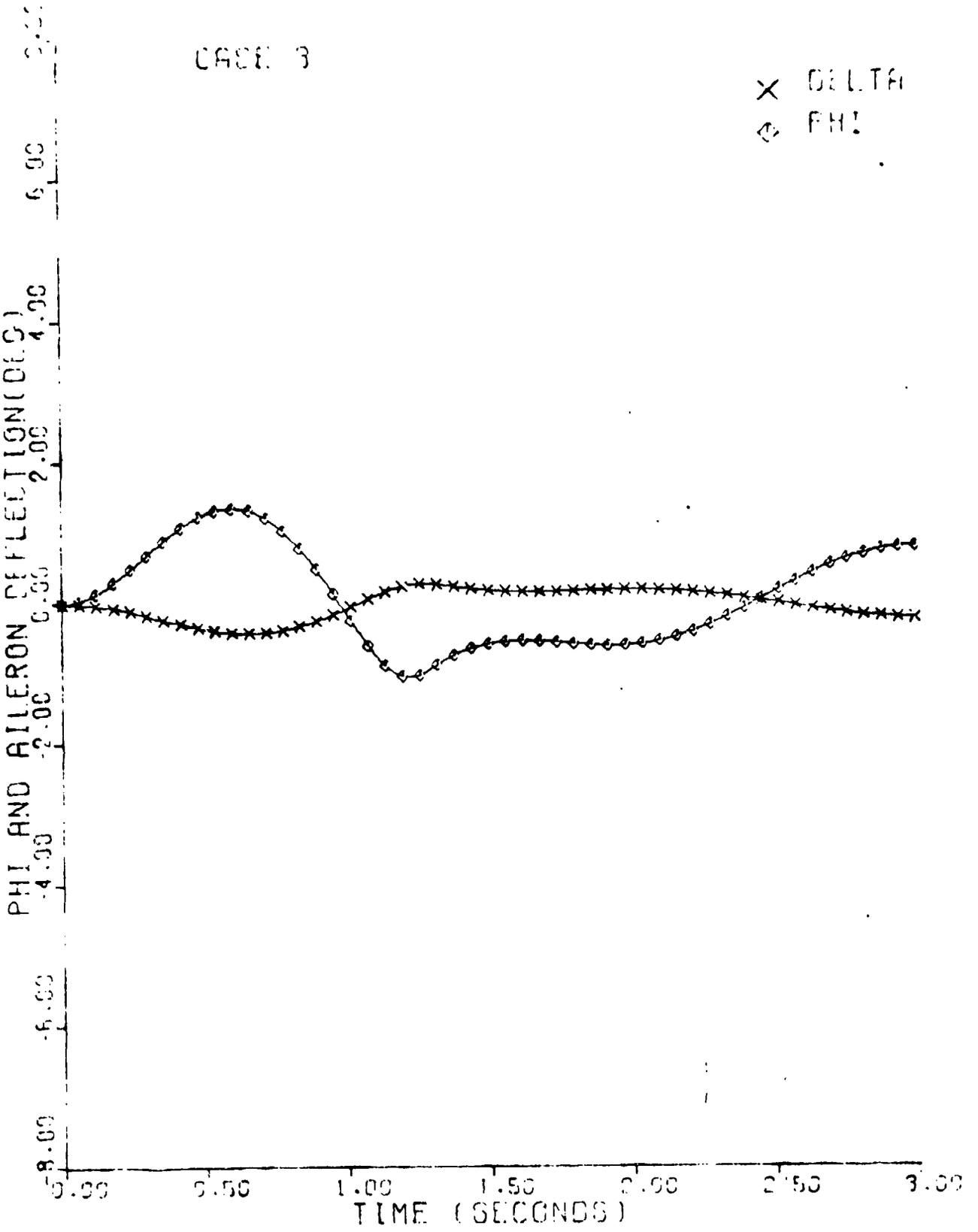

Figure 20. MQM-74C Roll Angle and Ailero Time History

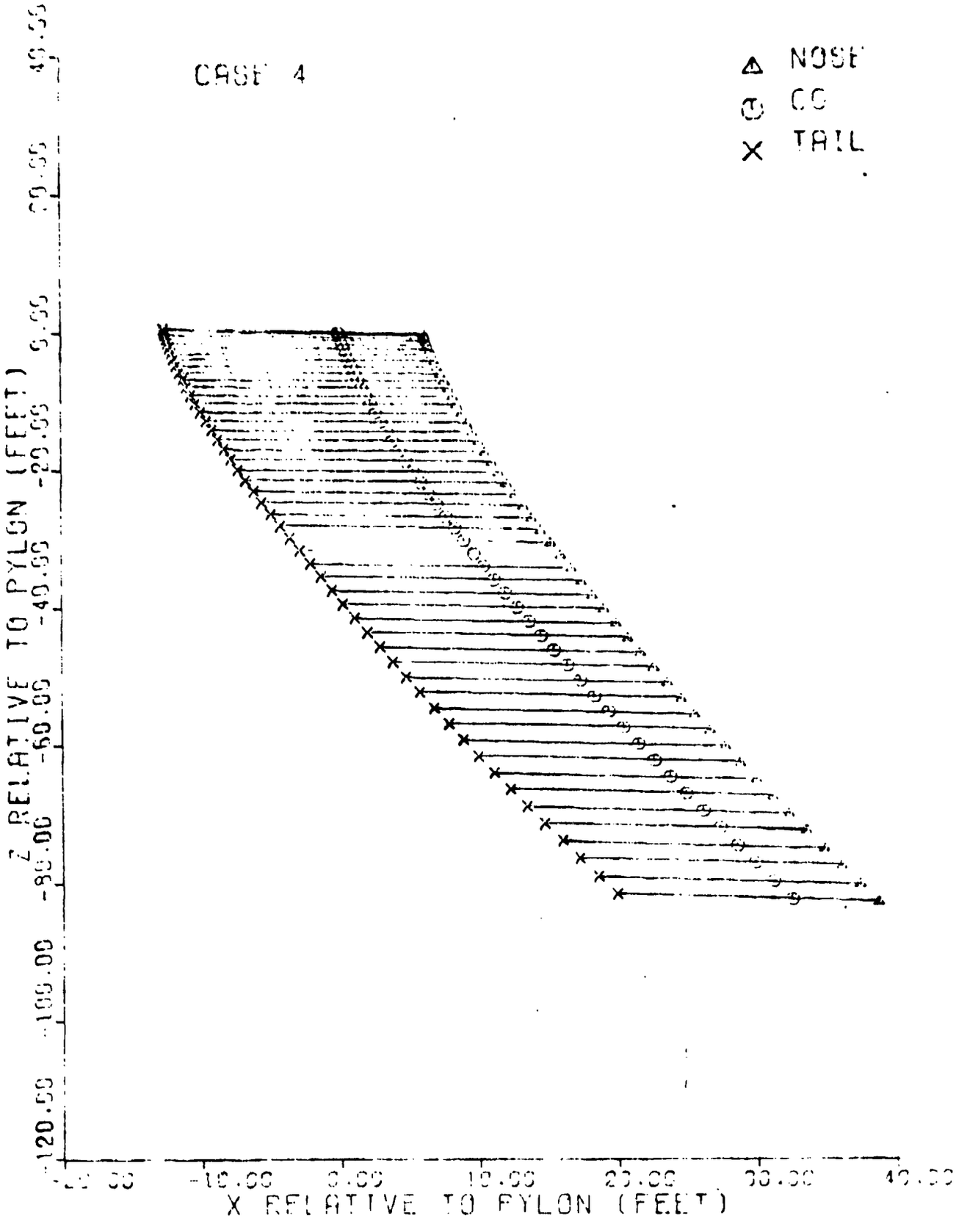

Figure 21. MQM-74C Longitudinal Separation Trajectory

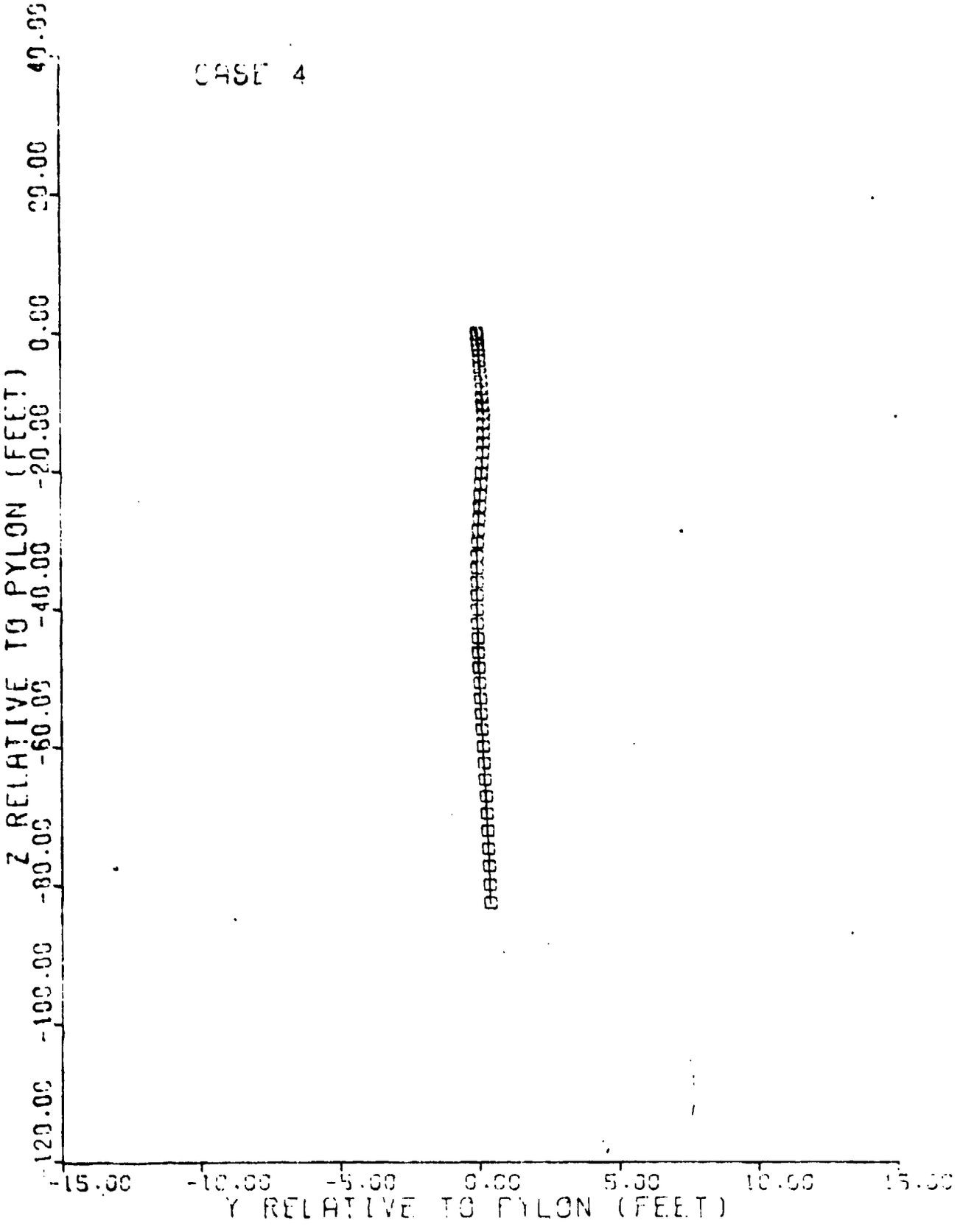

Figure 22. MQM-74C Lateral Separation Trajectory

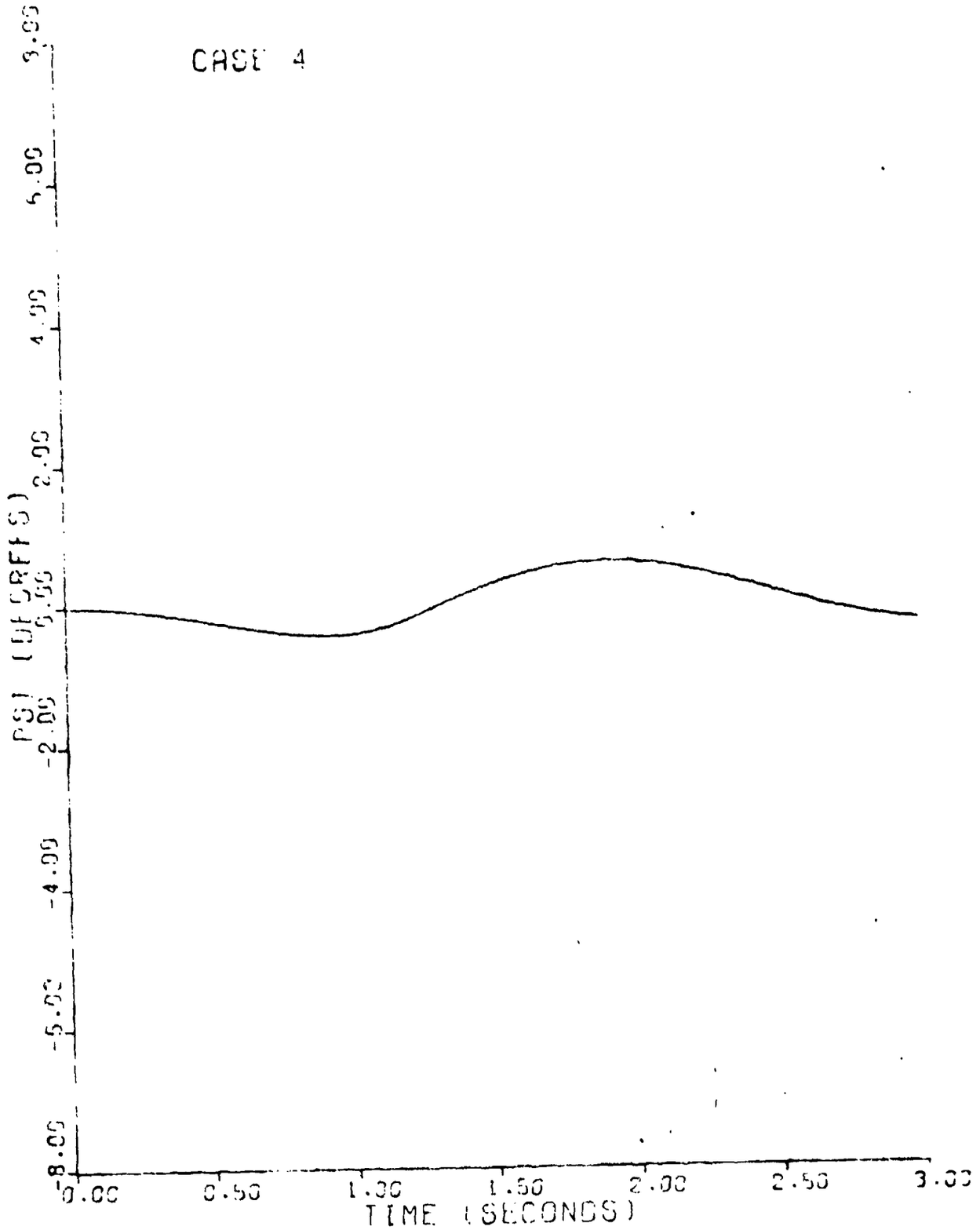

Figure 23. MQM-74C Yaw Time History

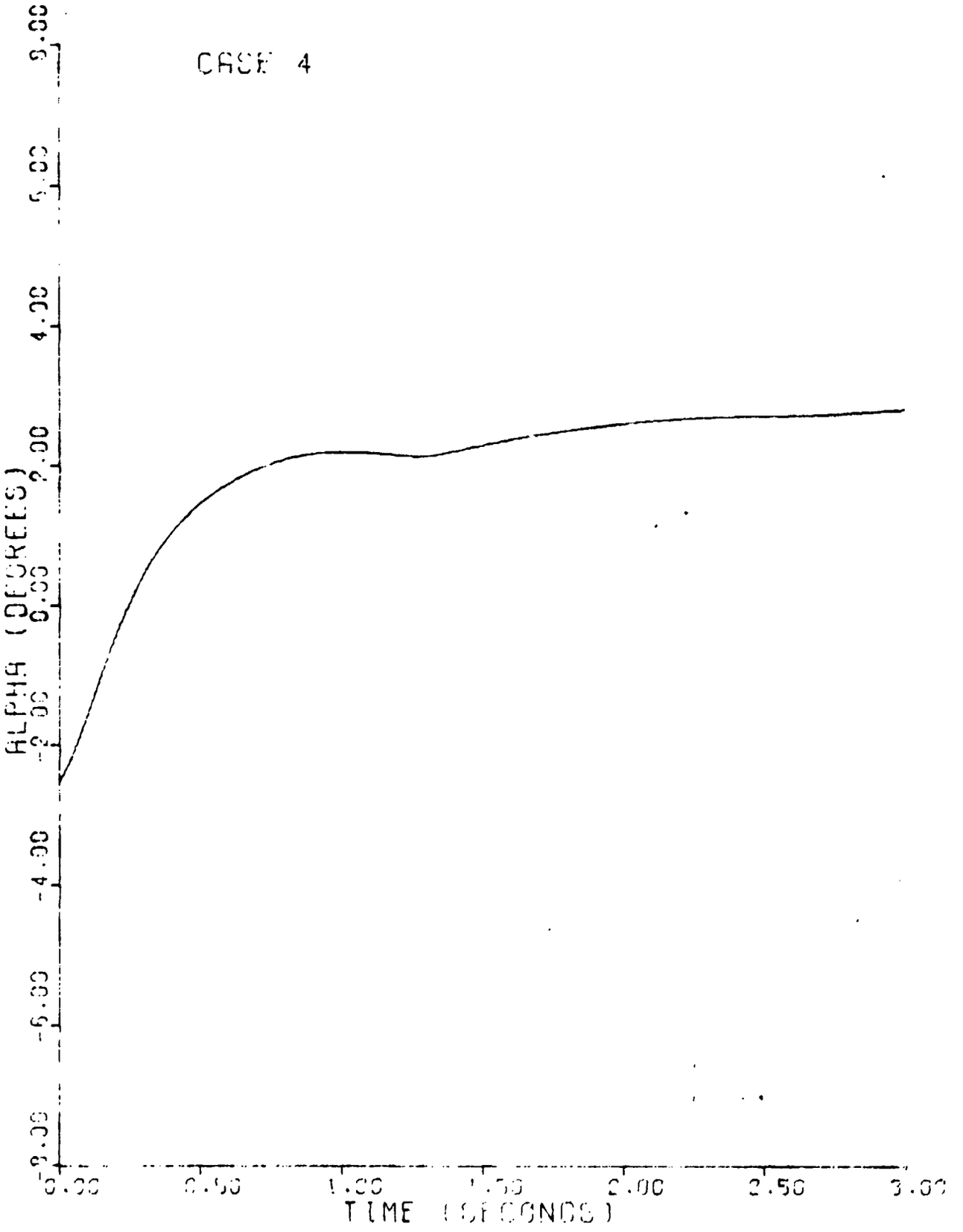

Figure 24. MQM-74C Angle of Attack Time History

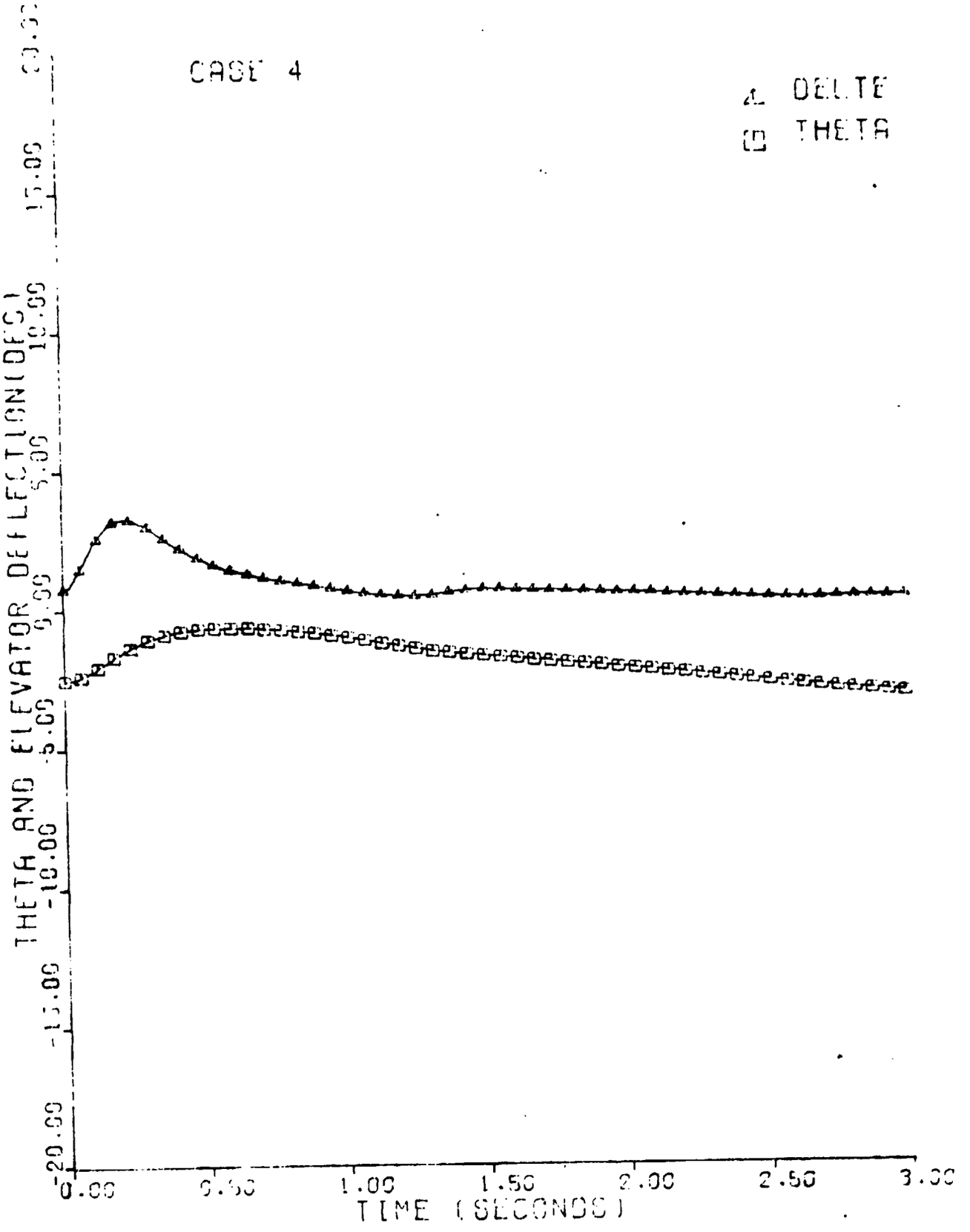

Figure 25. MQM-74C Pitch Attitude and Elevator Deflection Time History

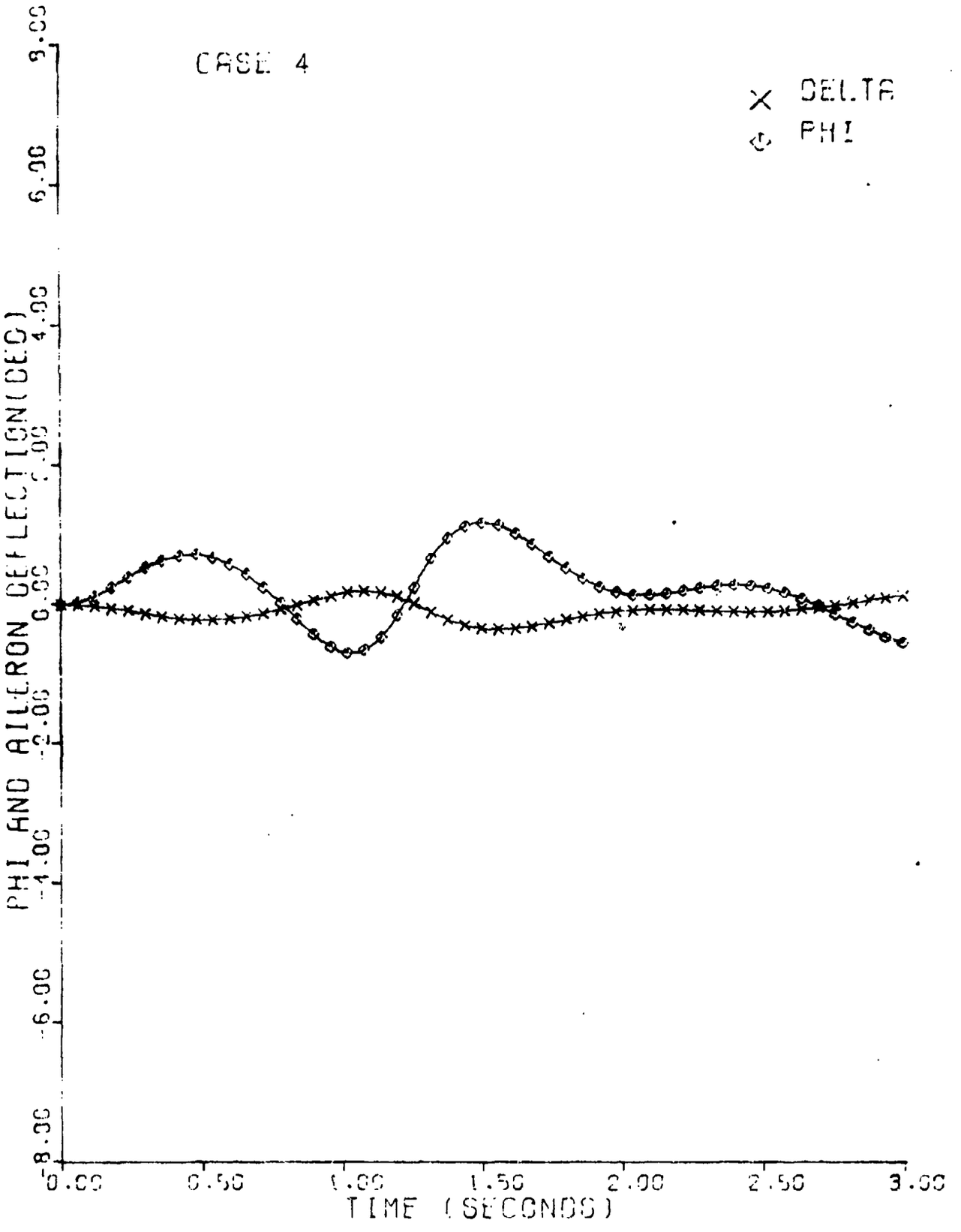

Figure 26. MQM-74C Roll Angle and Aileron Time History

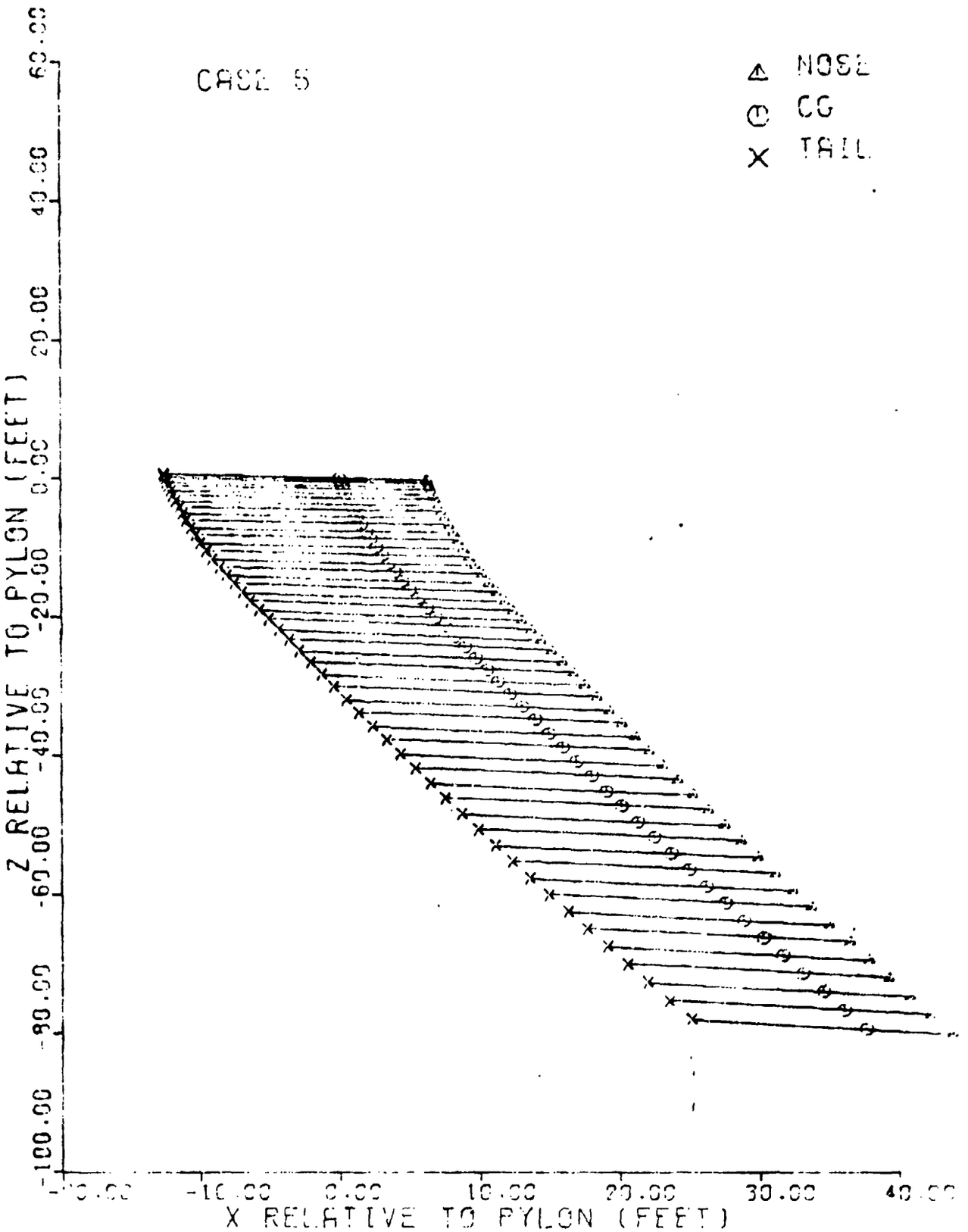

Figure 27. MQM-74C Longitudinal Separation Trajectory

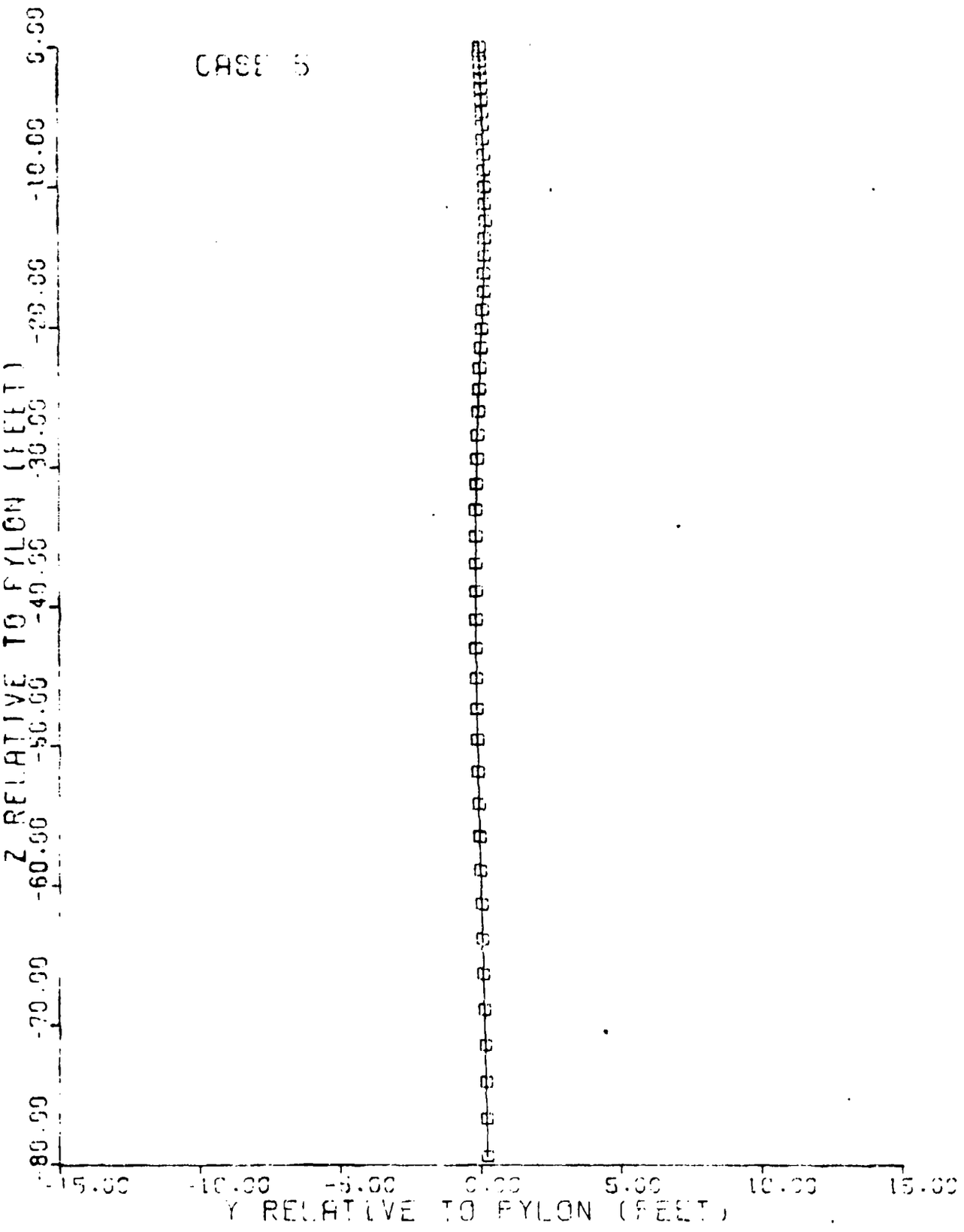

Figure 28. MQM-74C Lateral Separation Trajectory

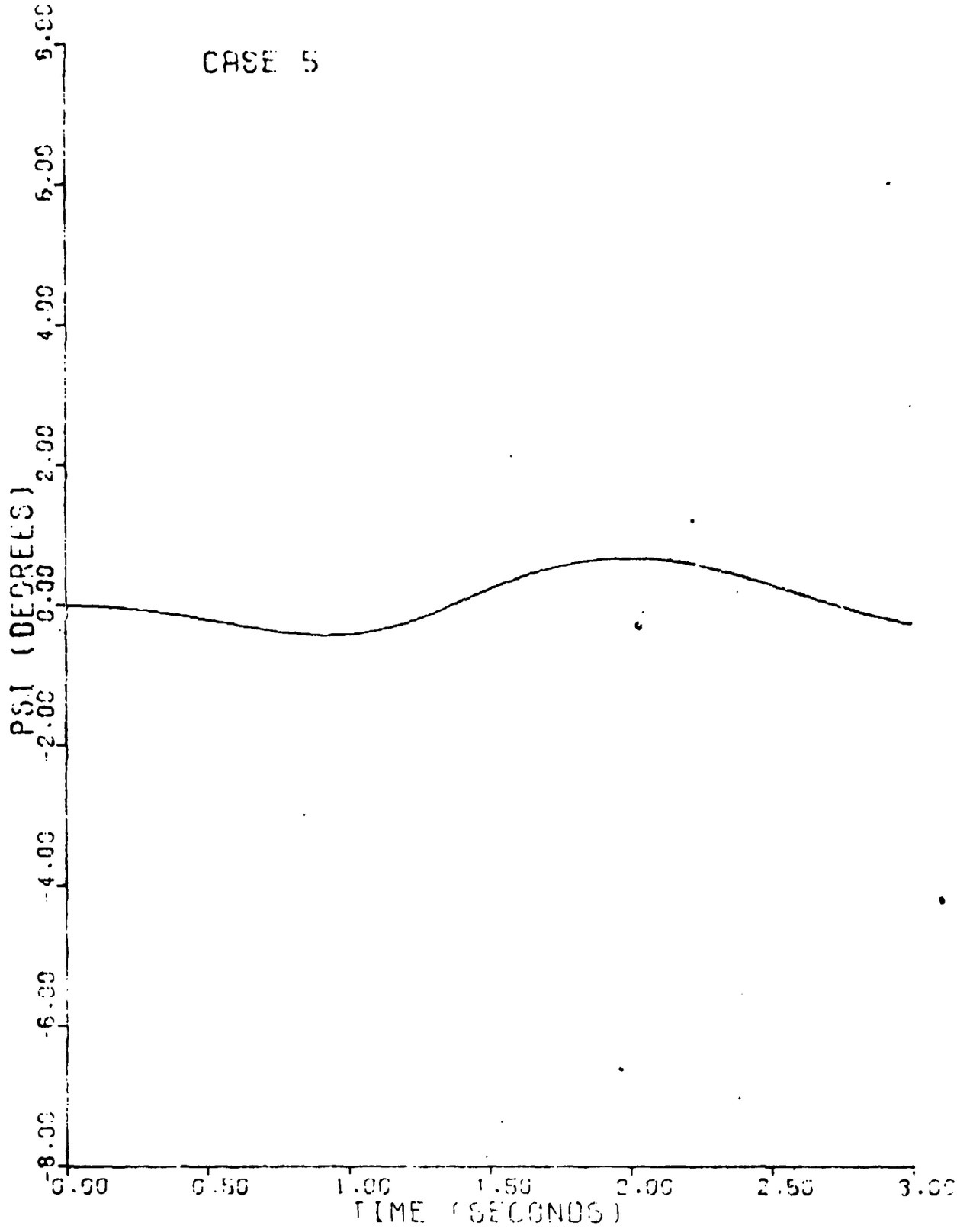

Figure 29. MQM-74C Yaw Time History

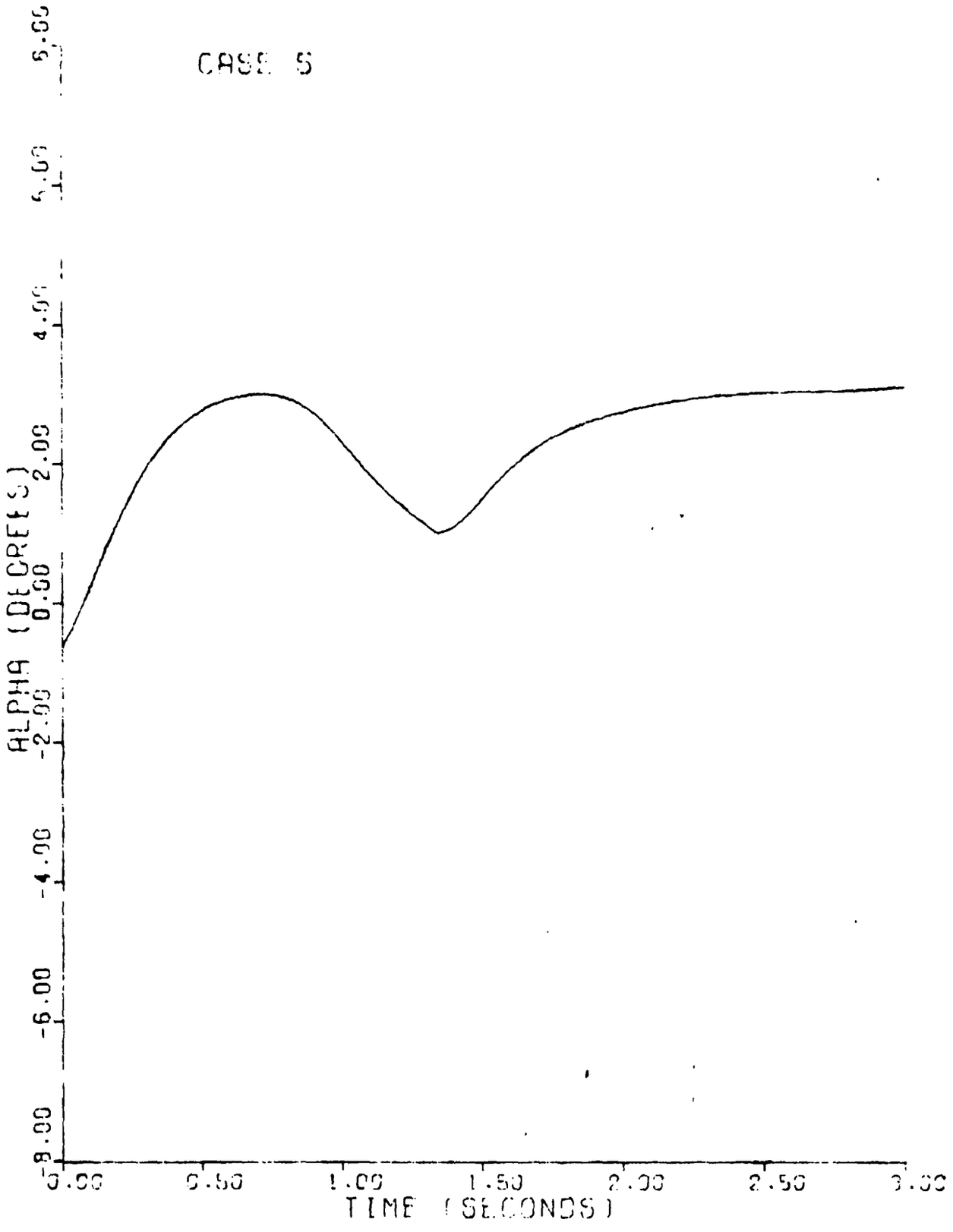

Figure 30. MQM-74C Angle of Attack Time History

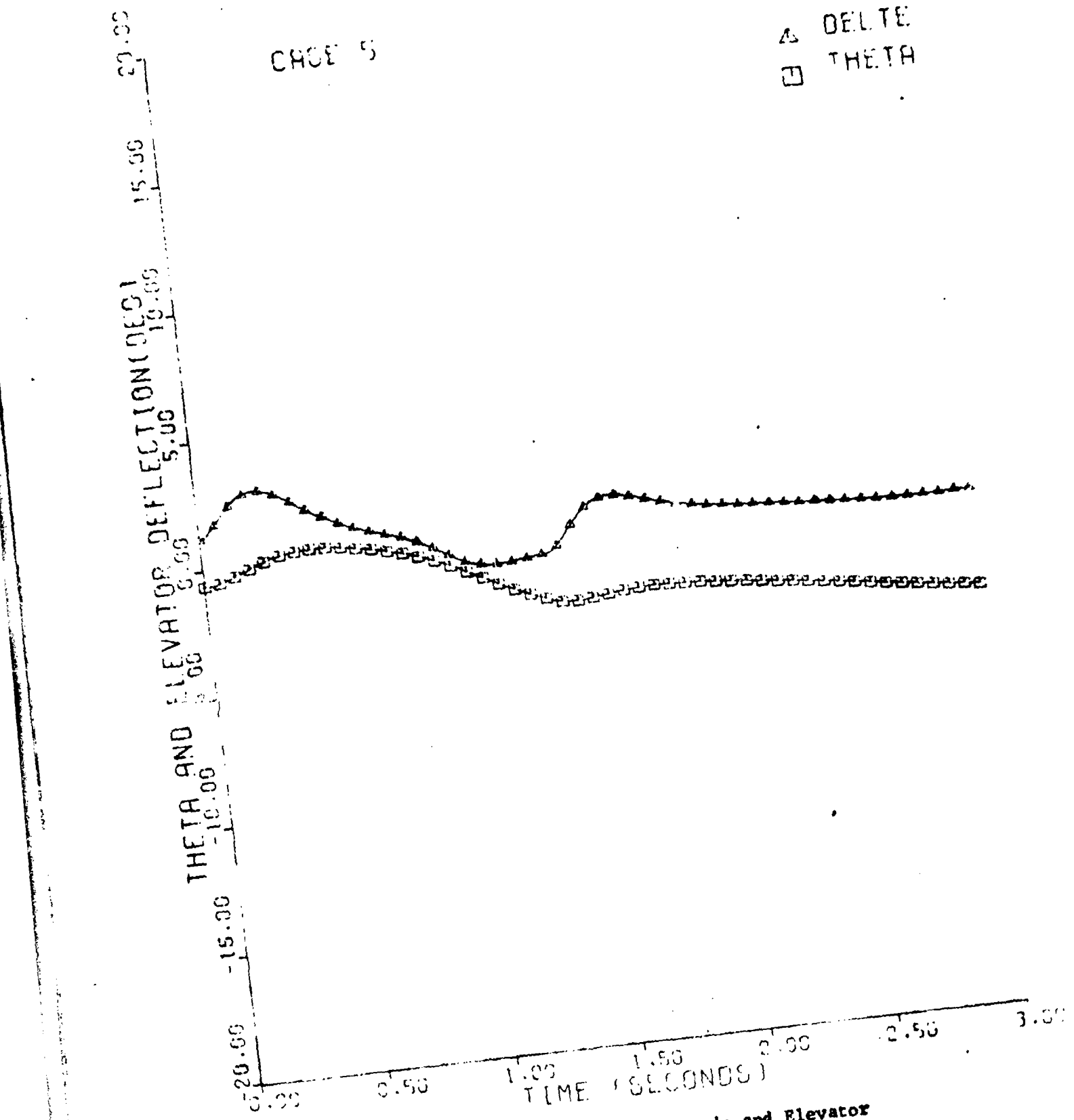

Figure 31. MQM-74C Pitch Attitude and Elevator Deflection Time History

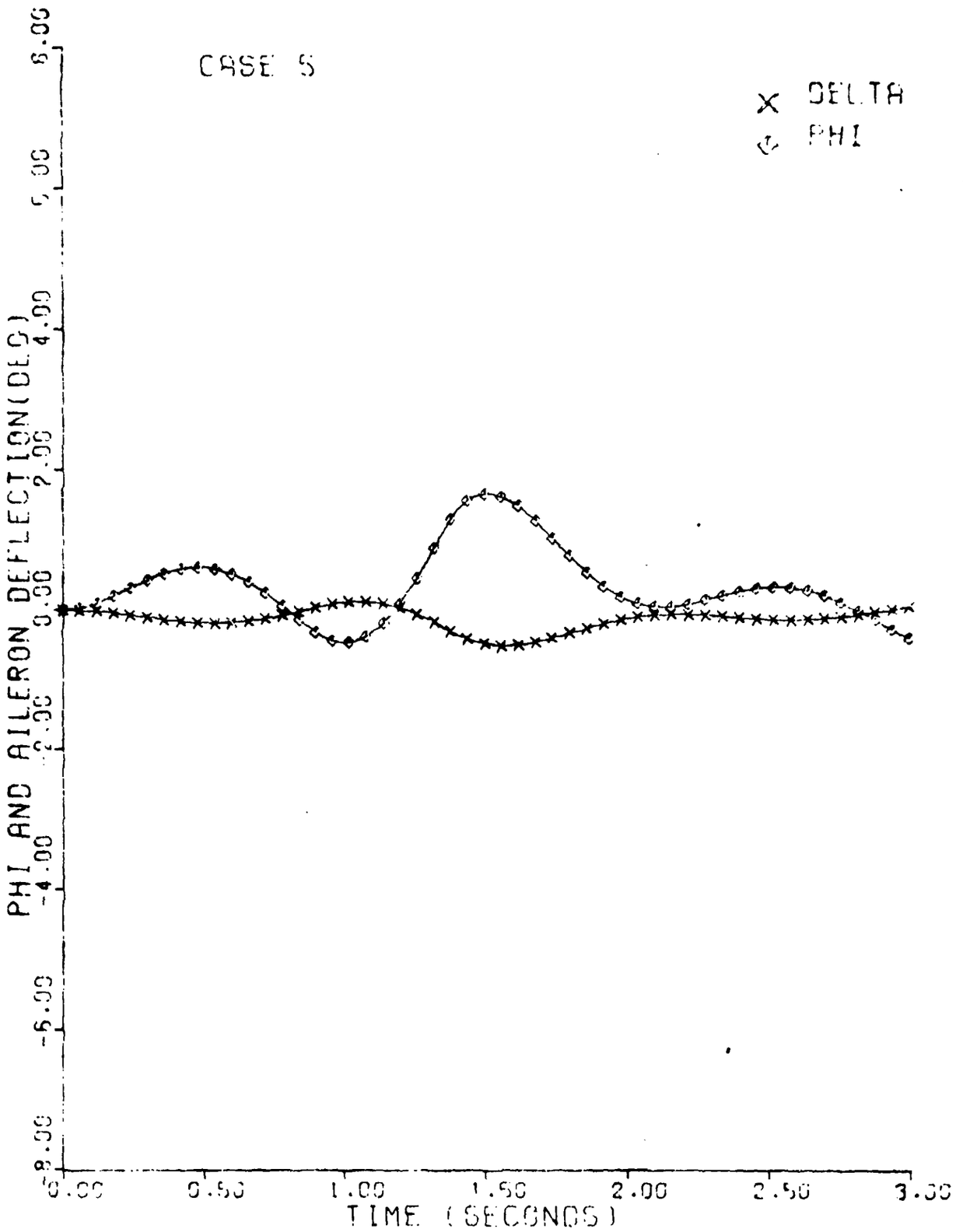

Figure 32. MQM-74C Roll Angle and Aileron Time History

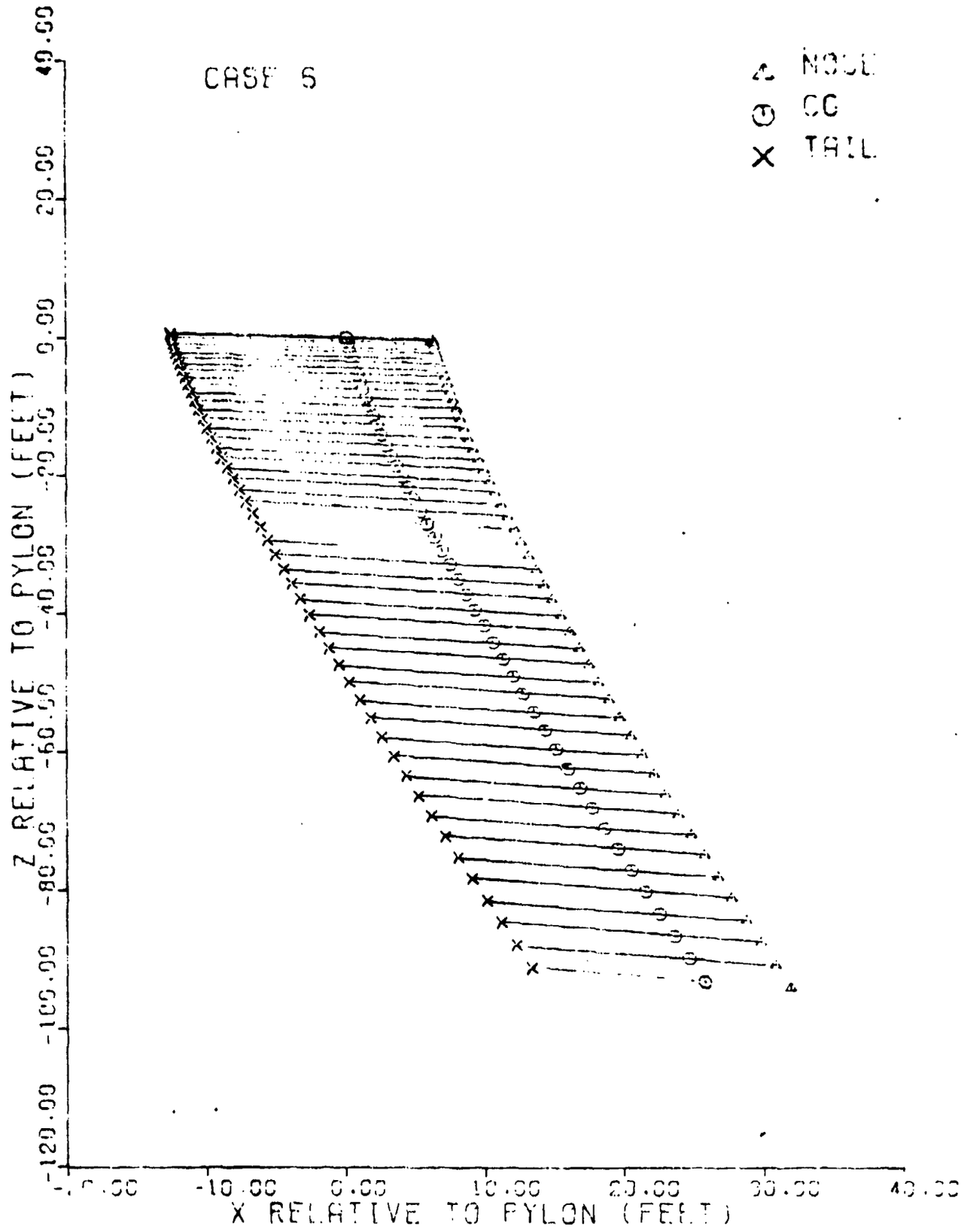

Figure 33. MQM-74C Longitudinal Separation Trajectory

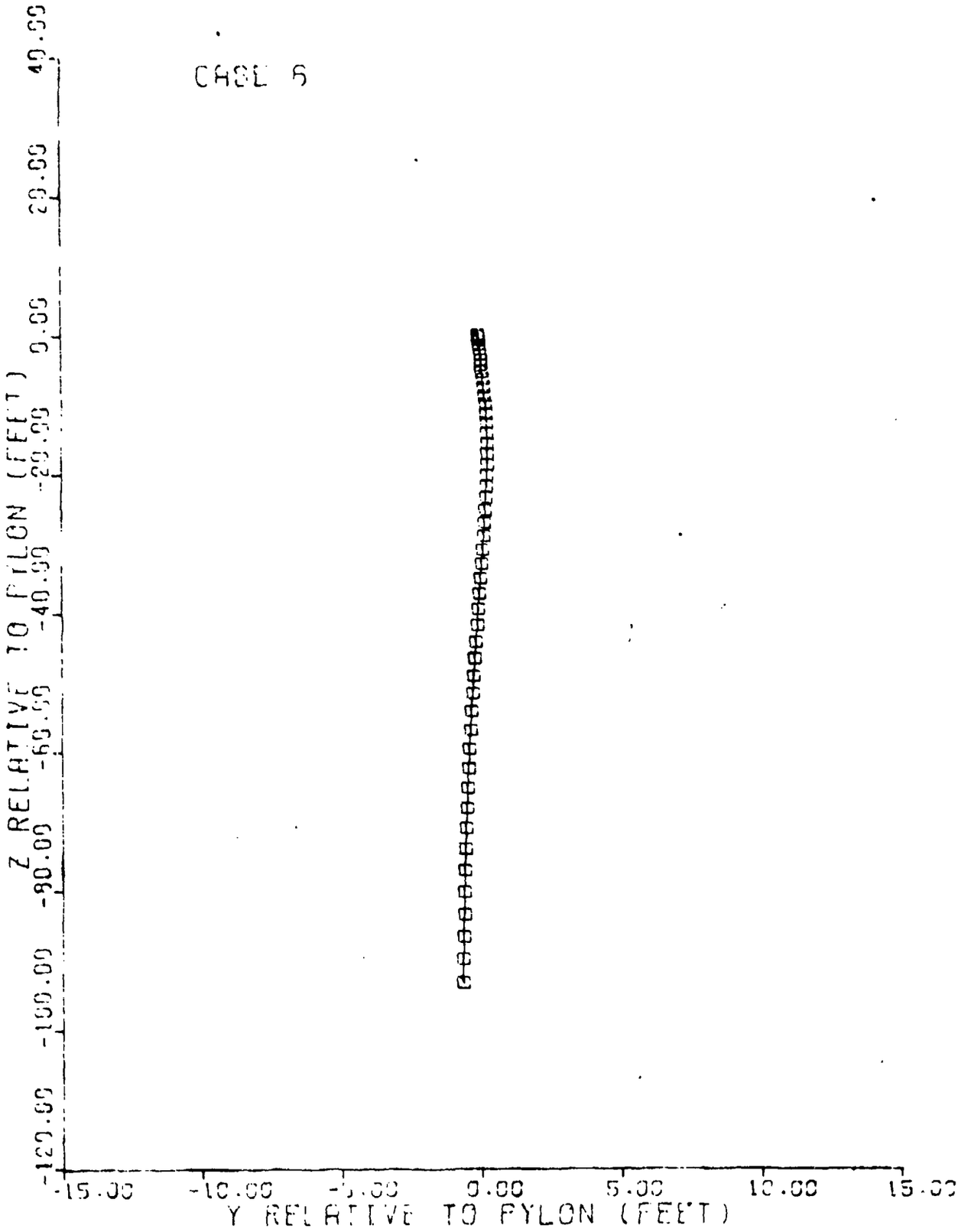

Figure 34. MQM-74C Lateral Separation Trajectory

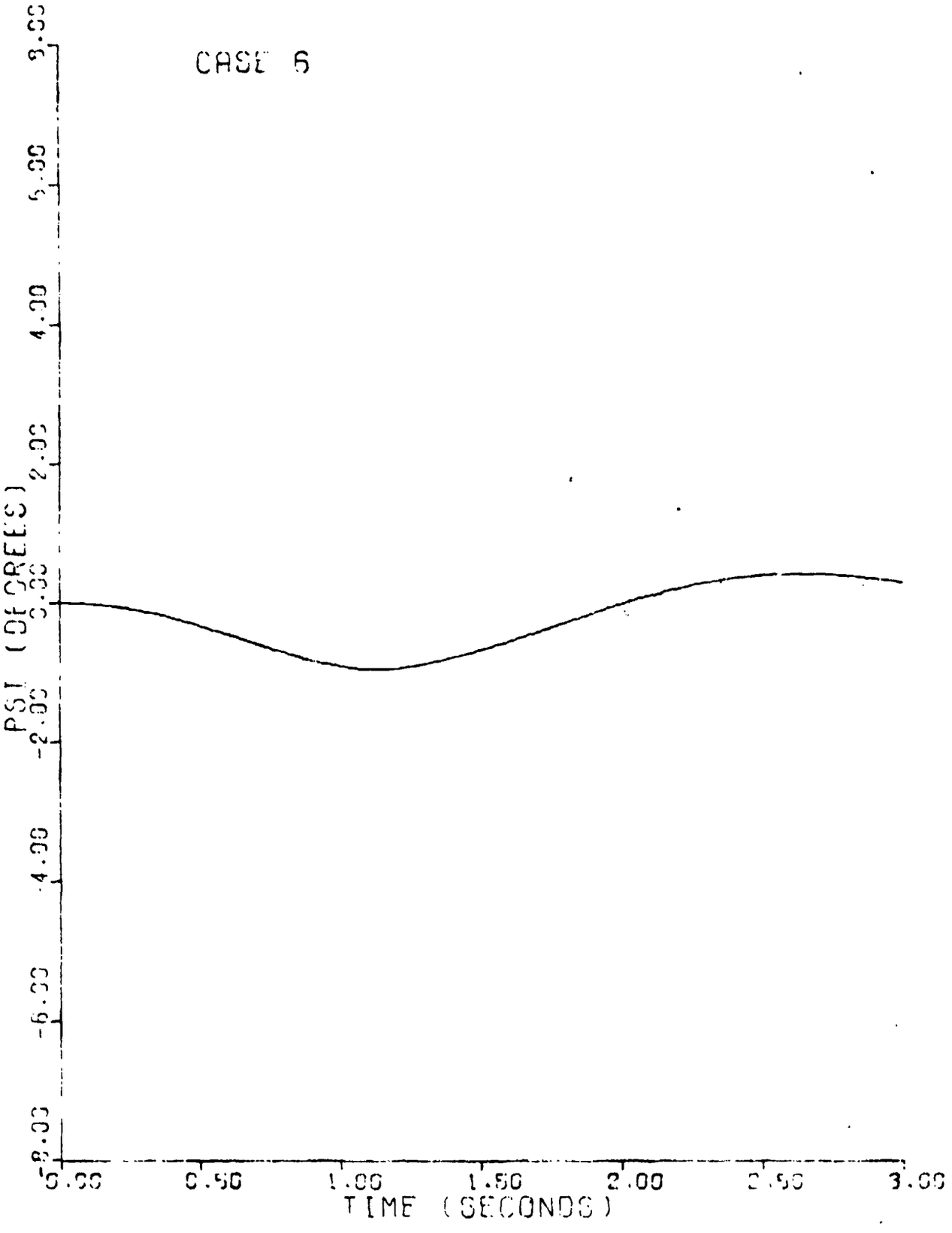

Figure 35. MQM-74C Yaw Time History

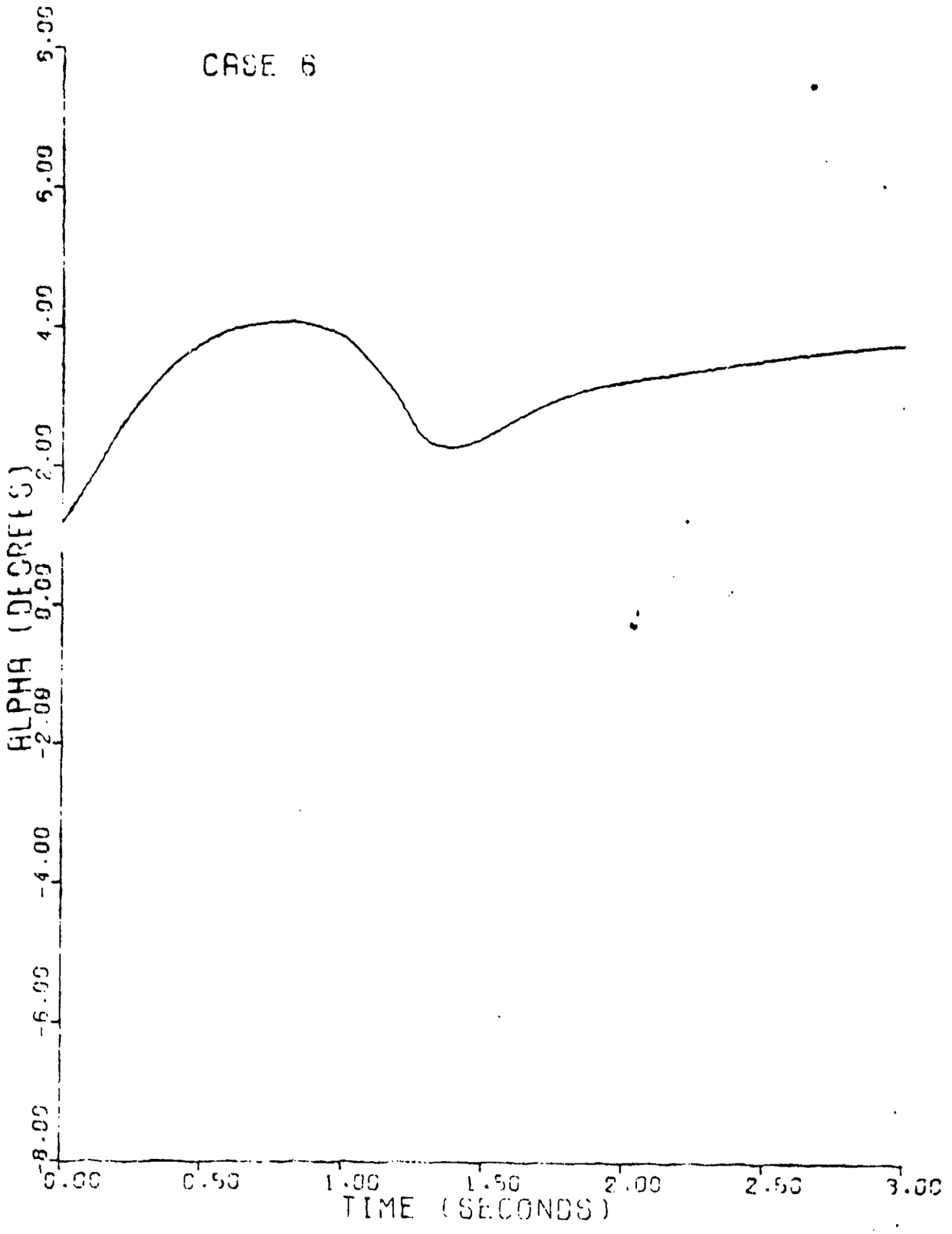

Figure 36. MQM-74C Angle of Attack Time History

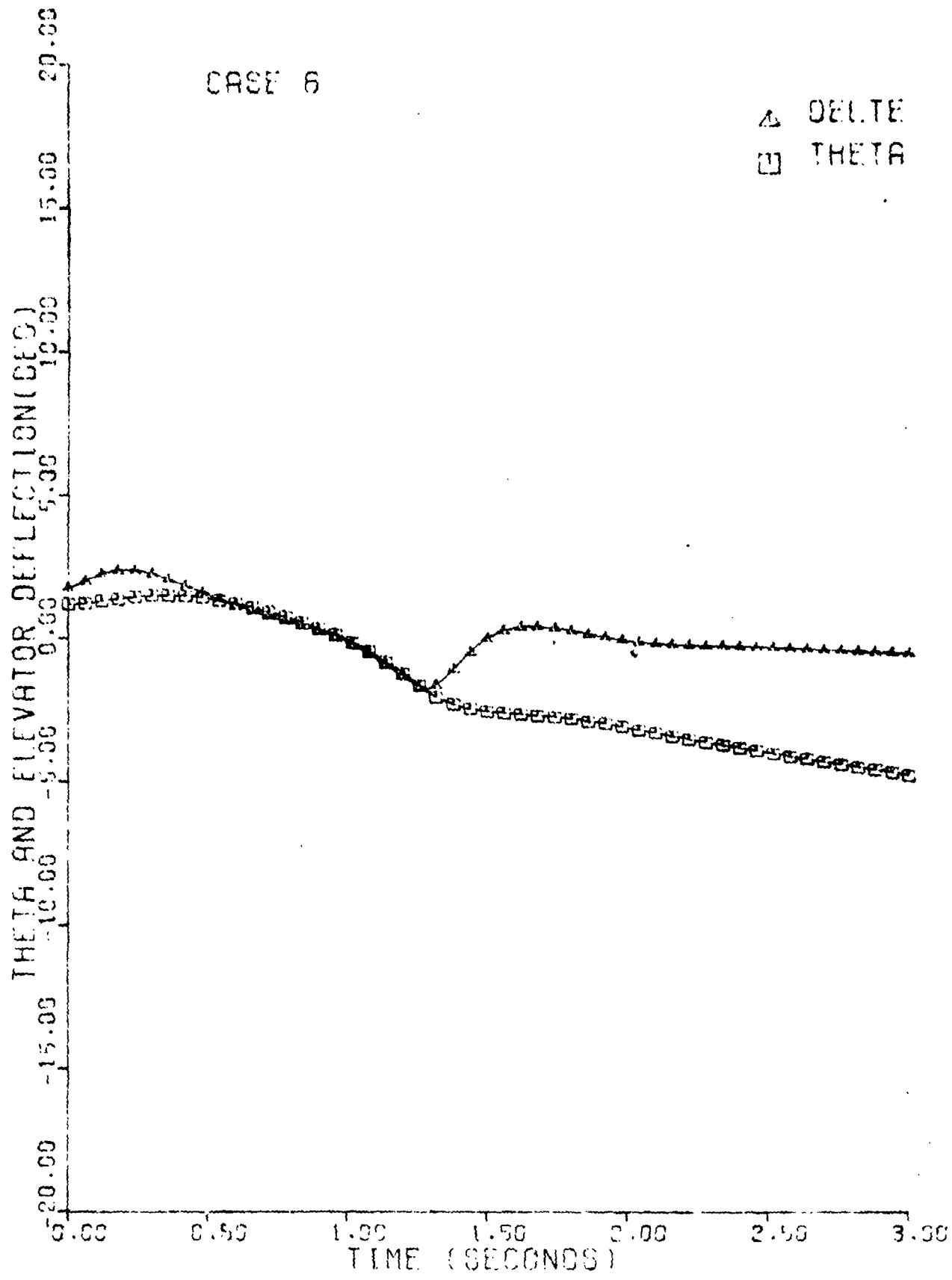

Figure 37. MQM-74C Pitch Attitude and Elevator Deflection Time History

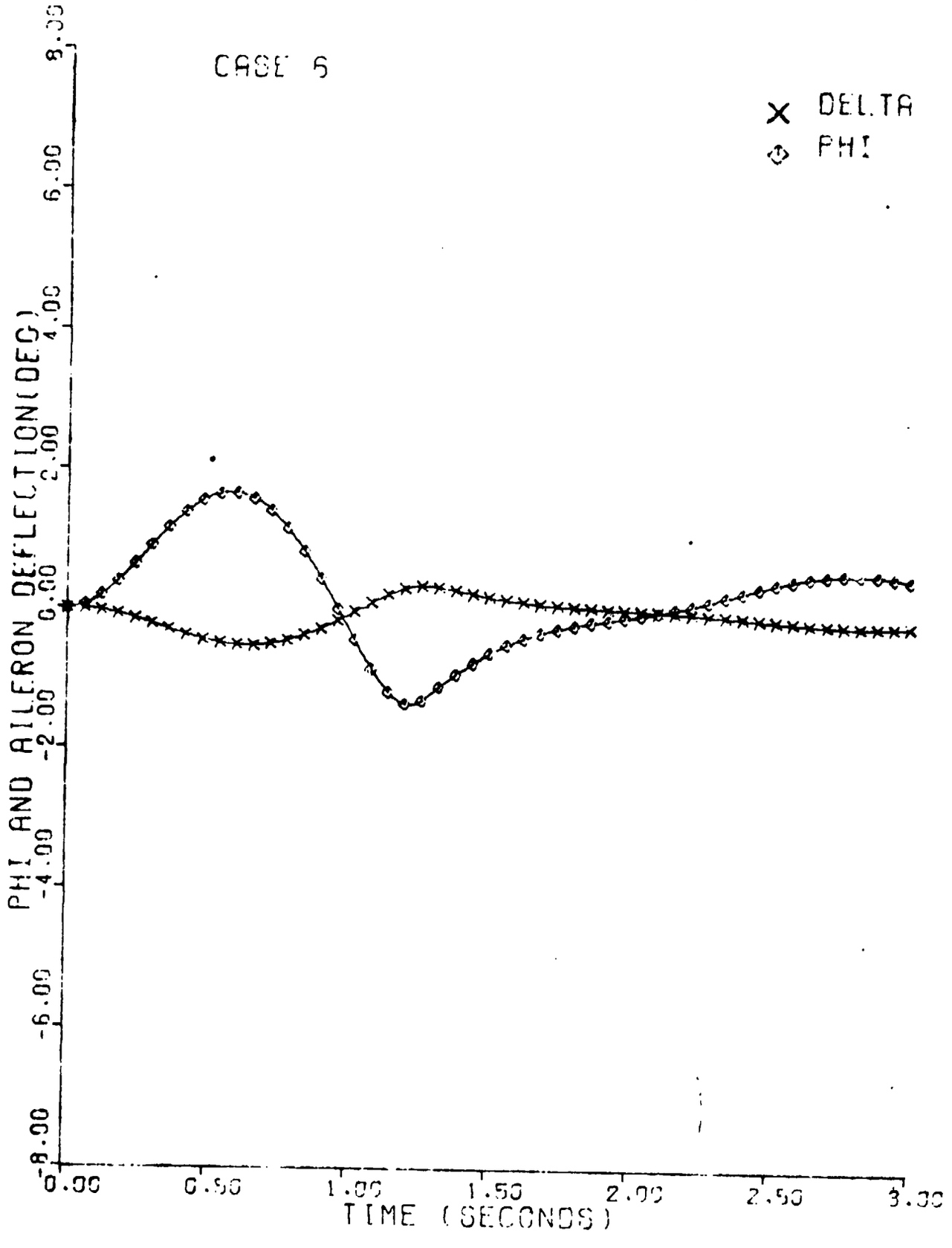

Figure 38. MQM-74C Roll Angle and Aileron Time History

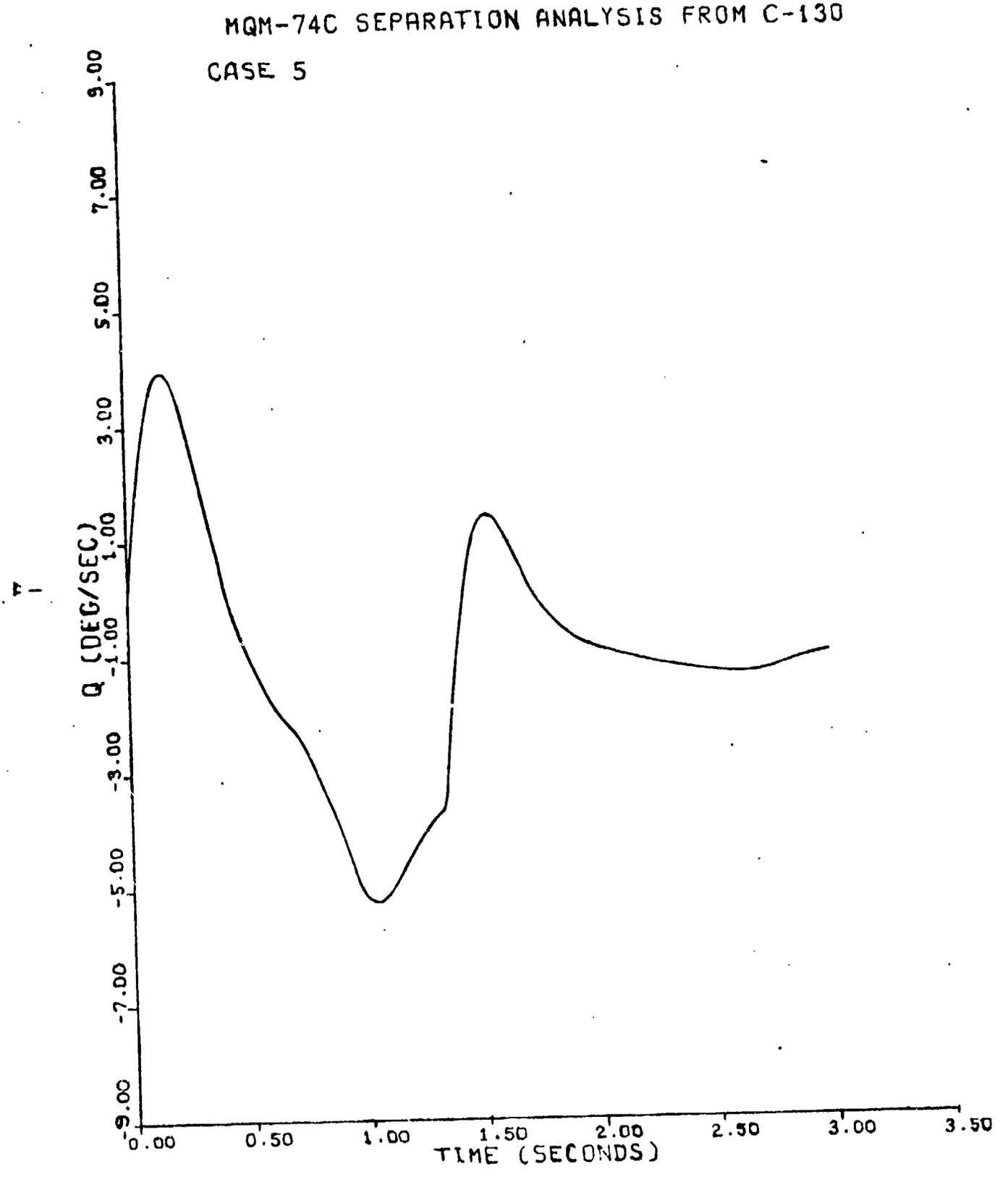

Figure 39. MQM-74C Pitch Rate Time History

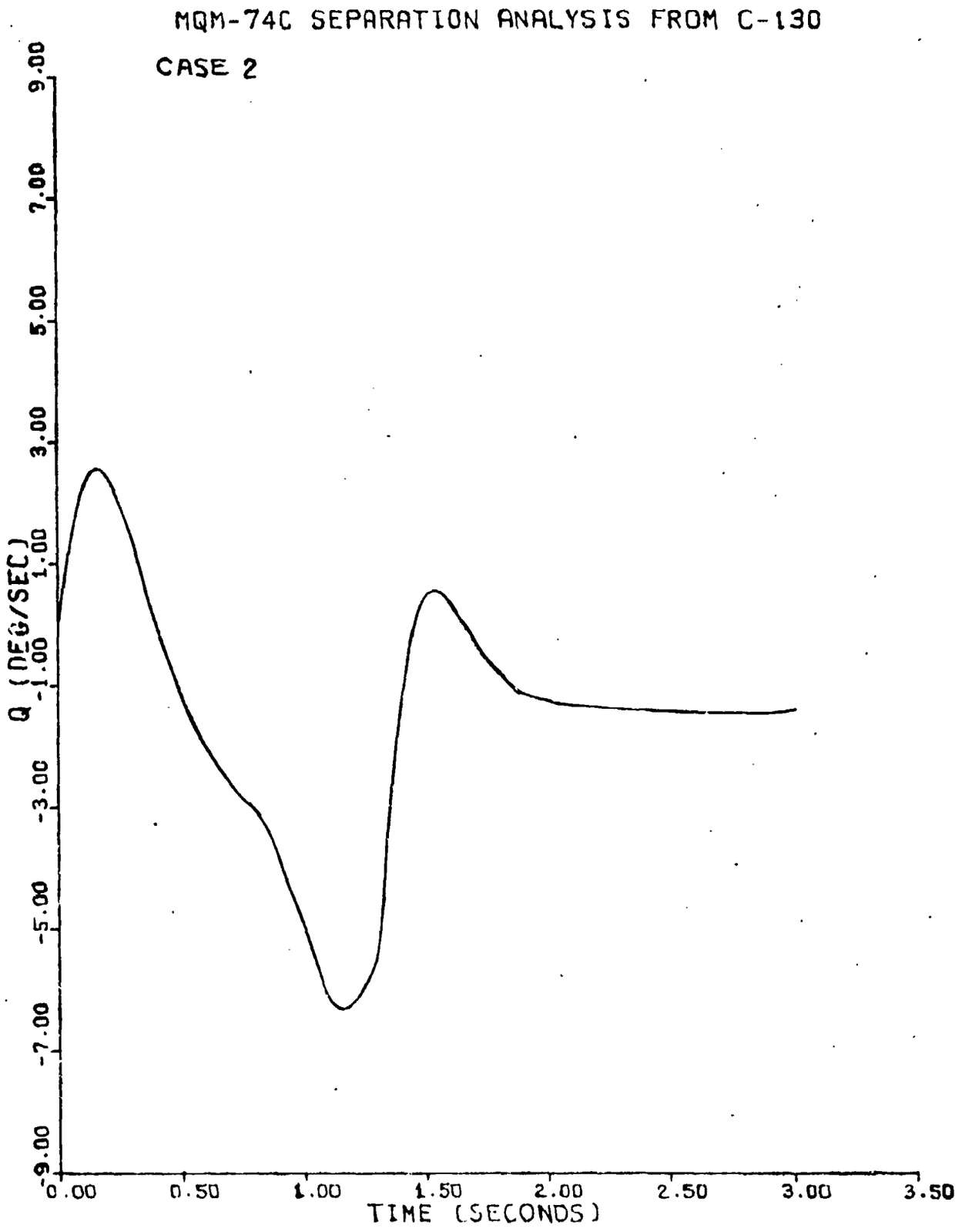

Figure 40. MQM-74C Pitch Rate Time History

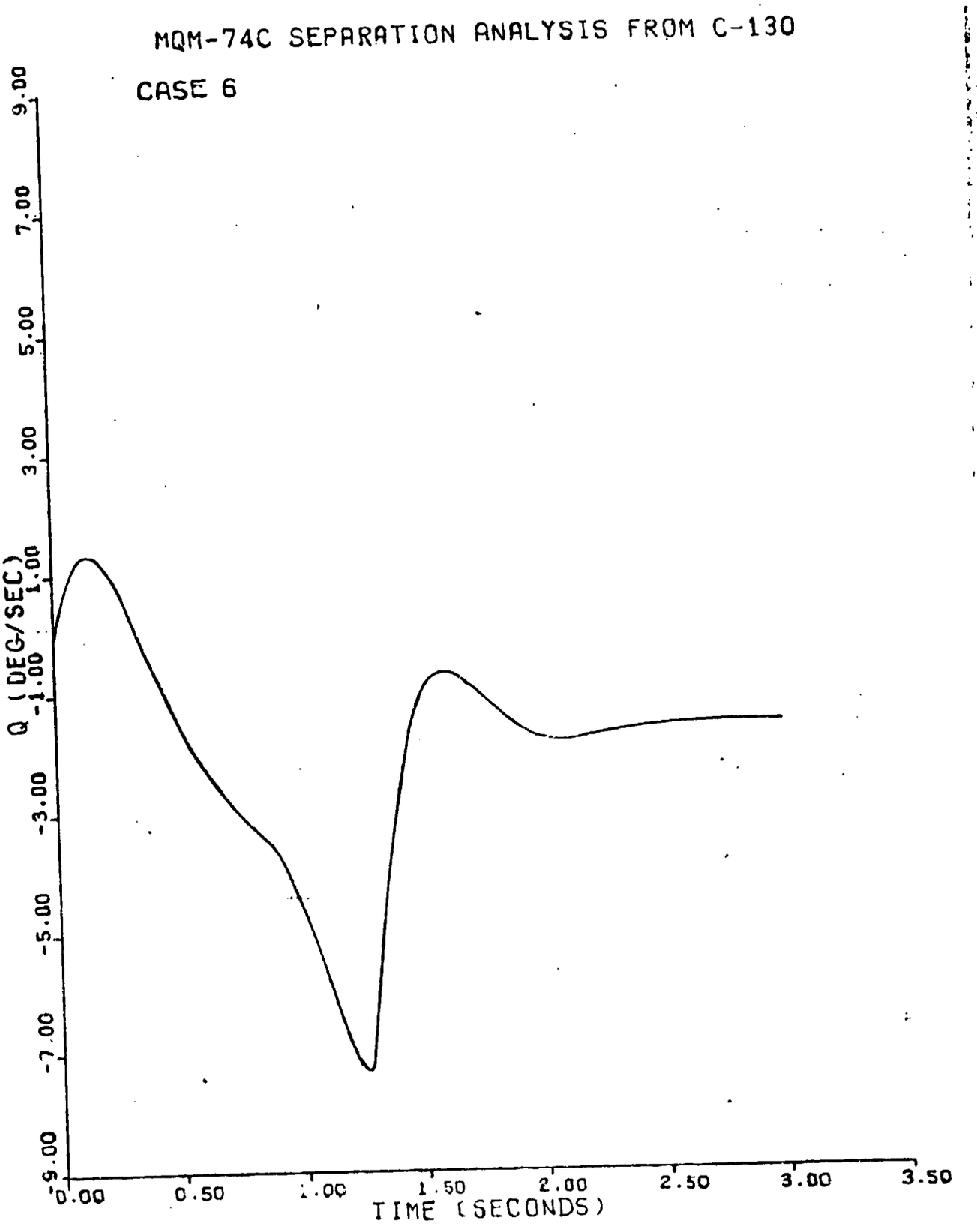

Figure 41. MQM-74C Pitch Rate Time History

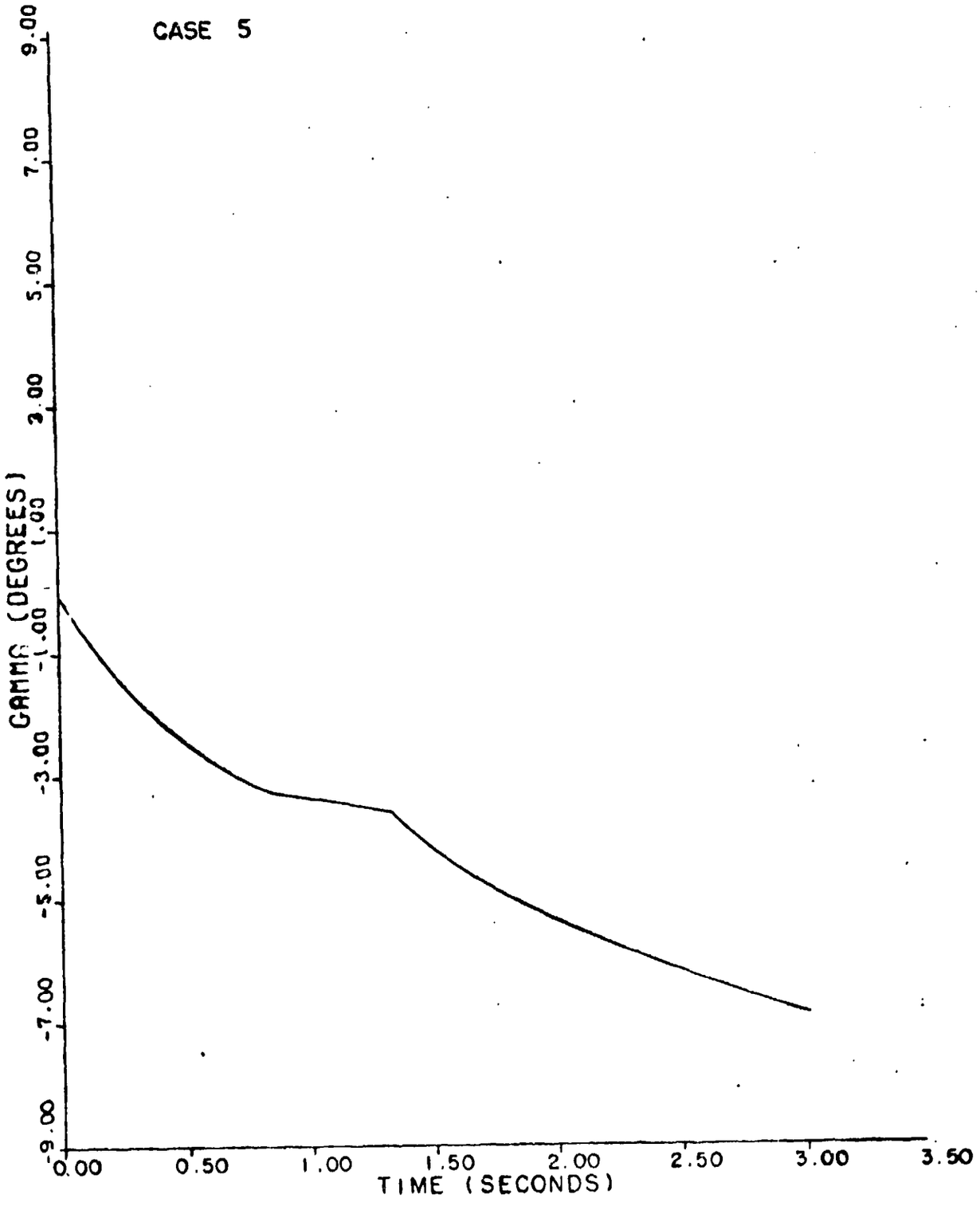

Figure 42. Flight Path Angle vs. Time

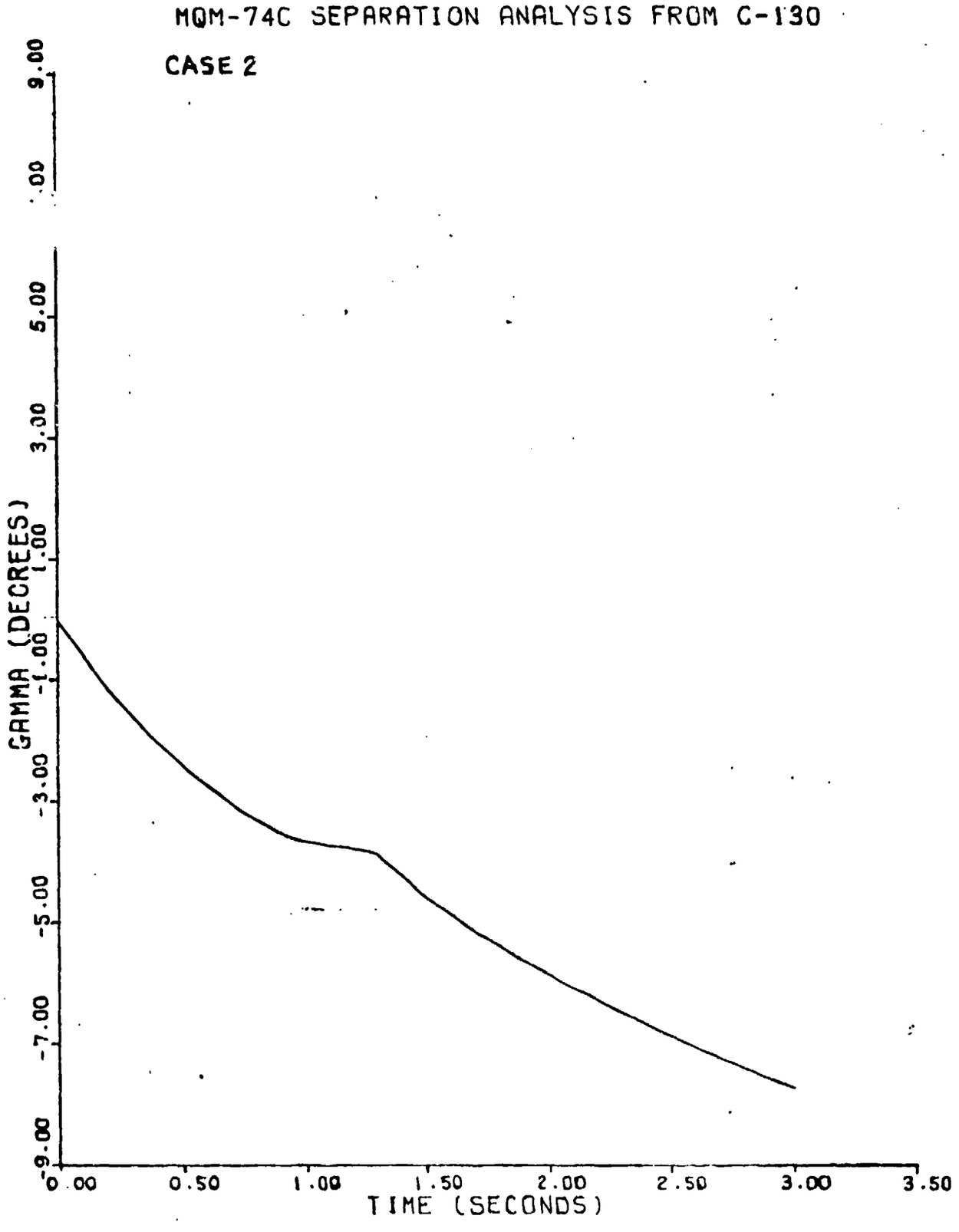

Figure 43. Flight Path Angle vs. Time

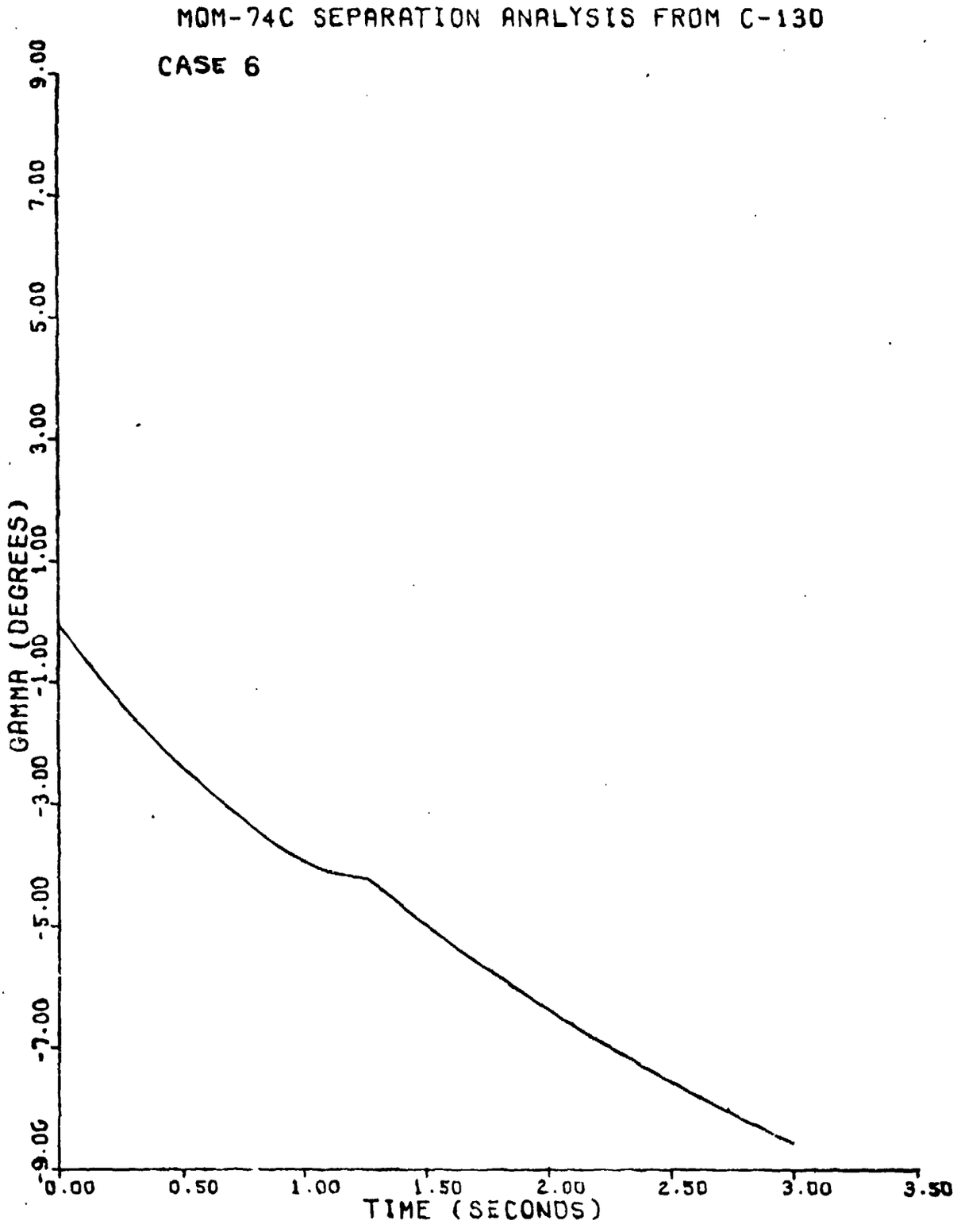

Figure 44. Flight Path Angle vs. Time

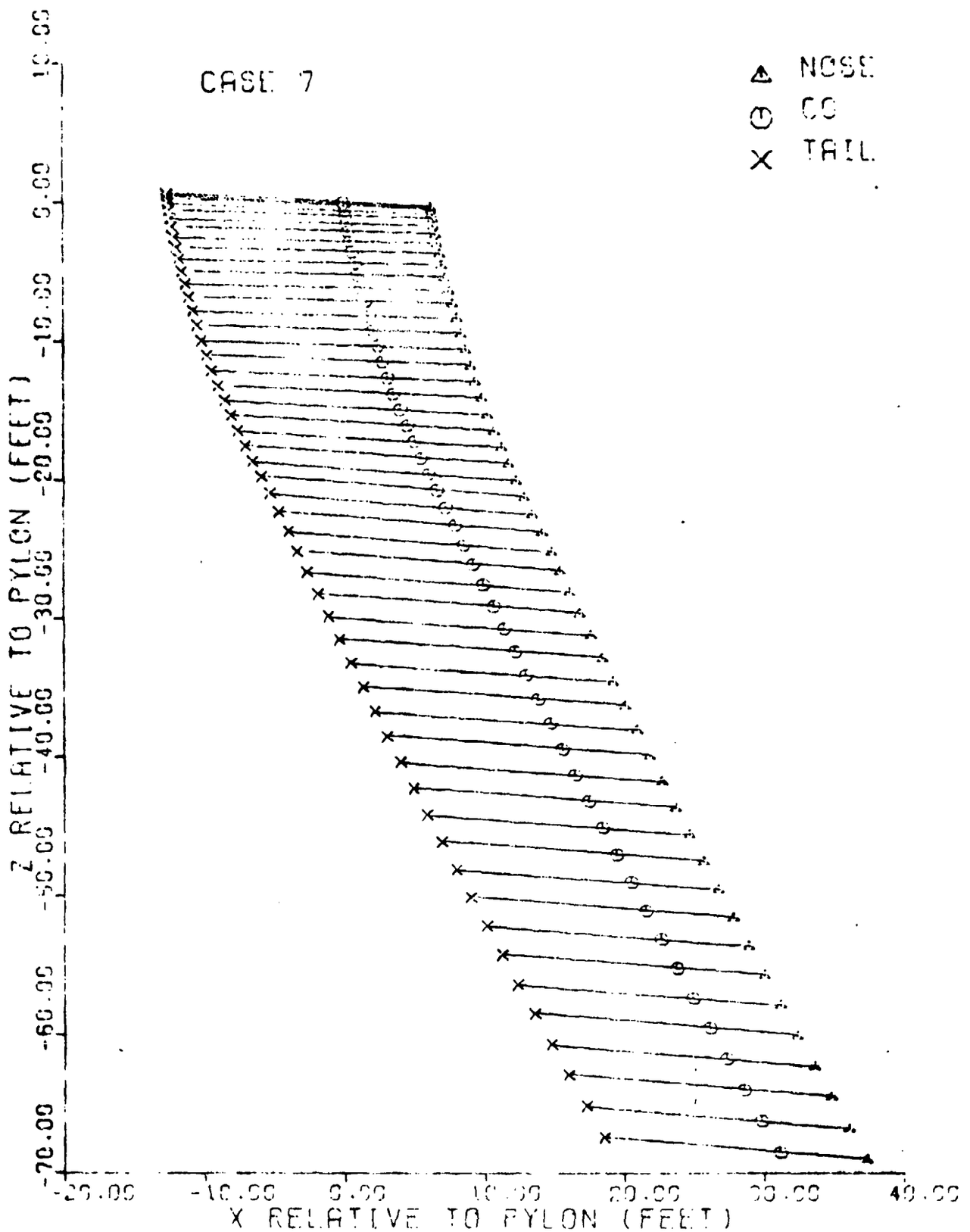

Figure 45. MQM-74C Longitudinal Separation Trajectory

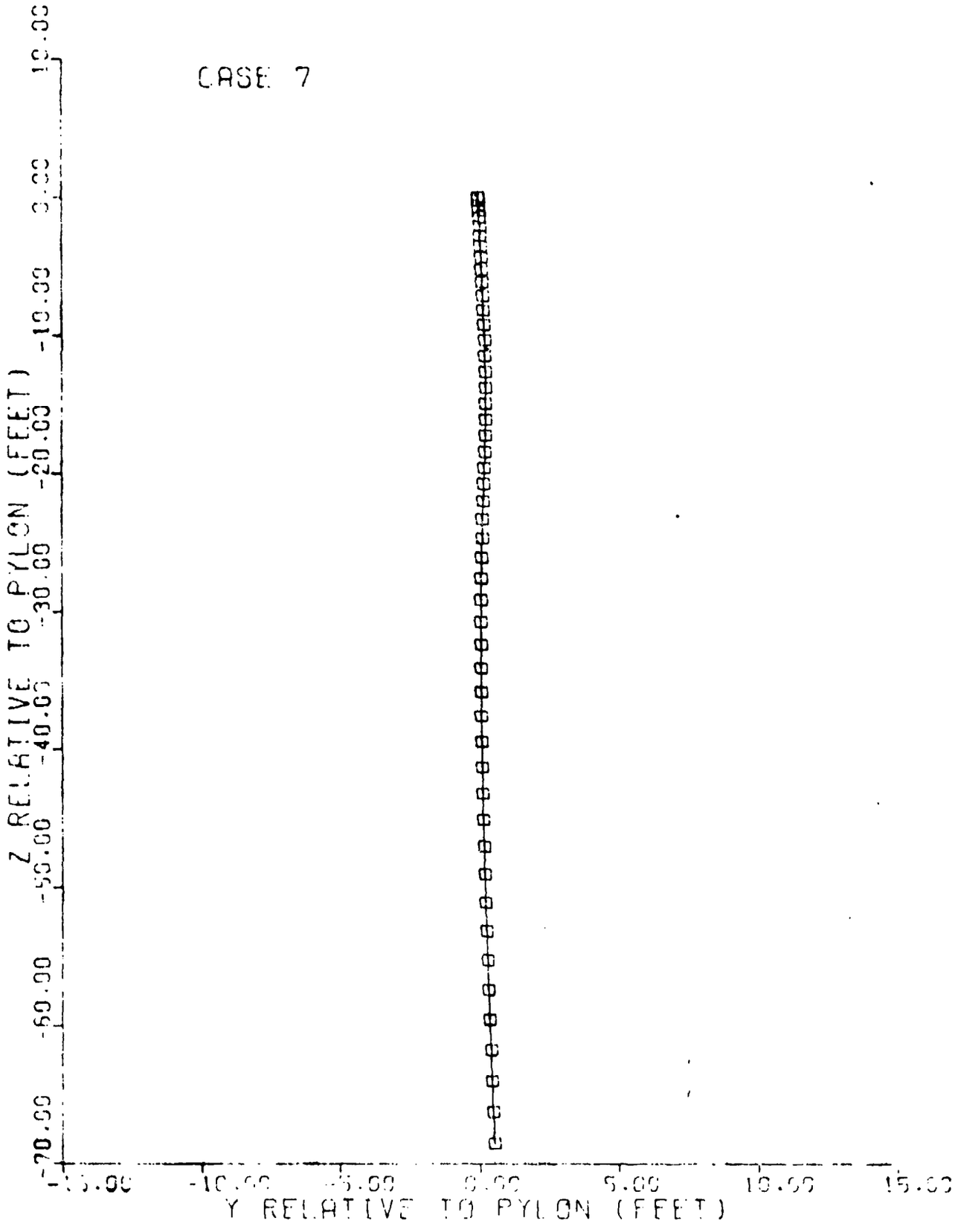

Figure 46. MQM-74C Lateral Separation Trajectory

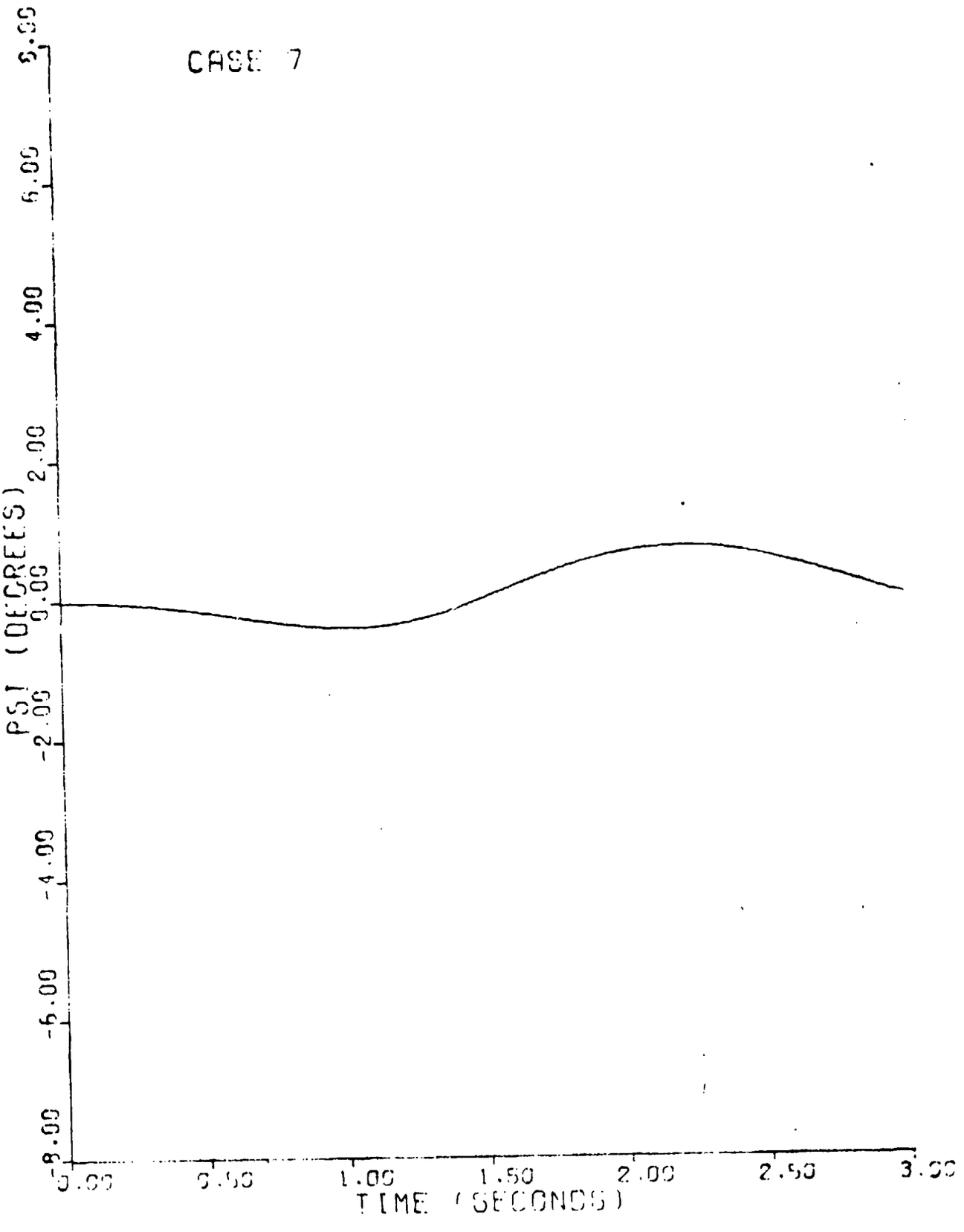

Figure 47. MQM-74C Yaw Time History

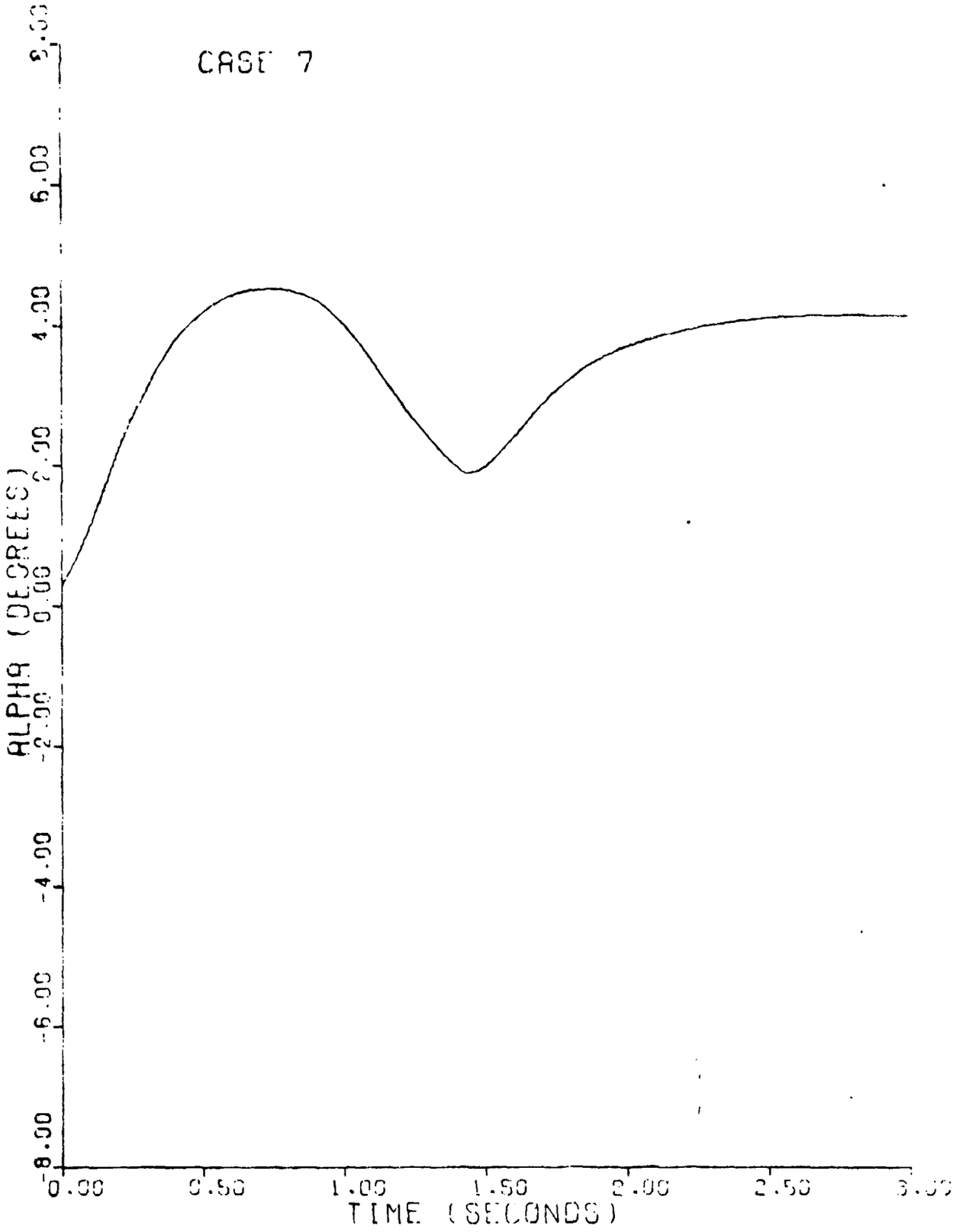

Figure 48. MQM-74C Angle of Attack Time History

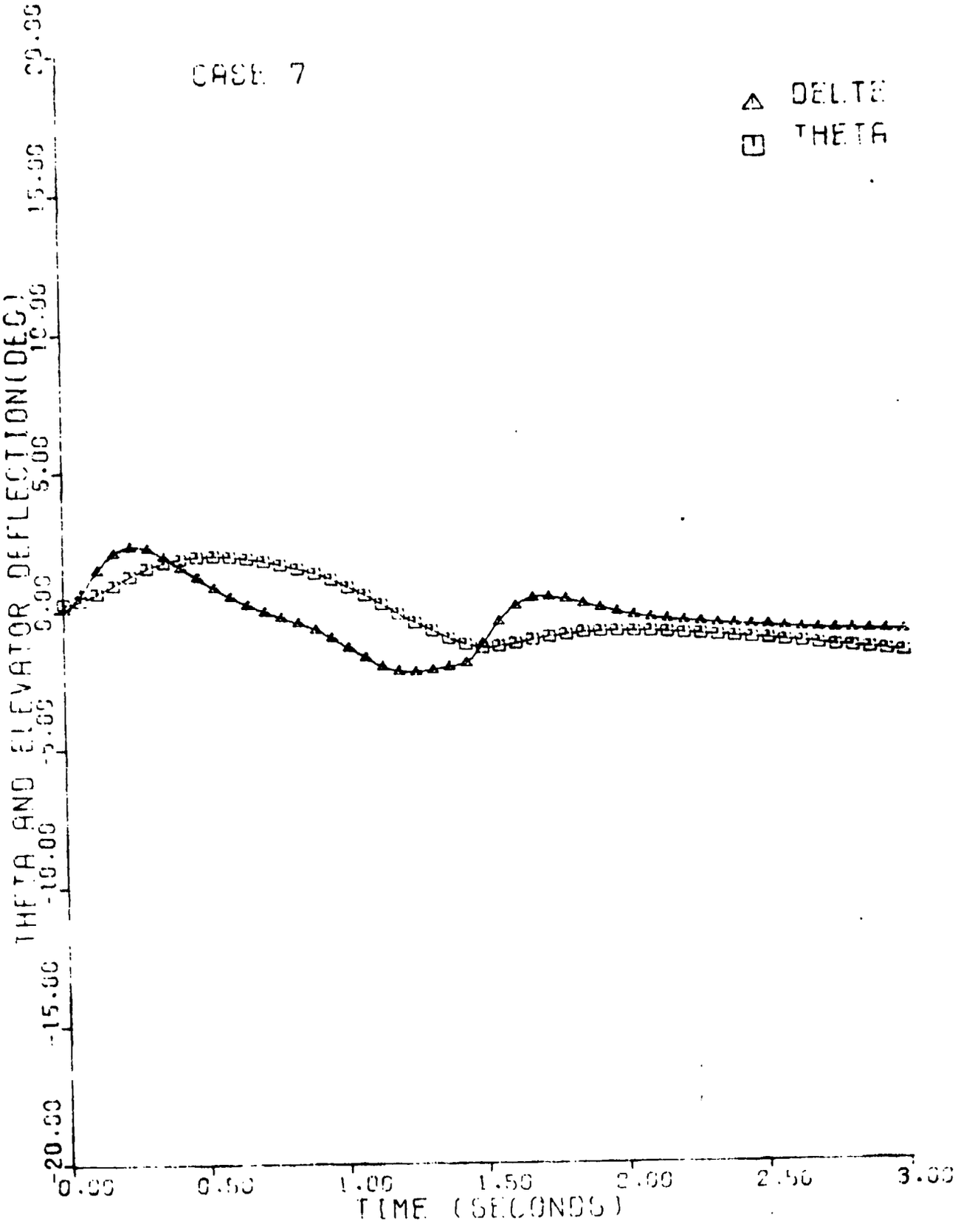

Figure 49. MQM-74C Pitch Attitude and Elevator Deflection Time History

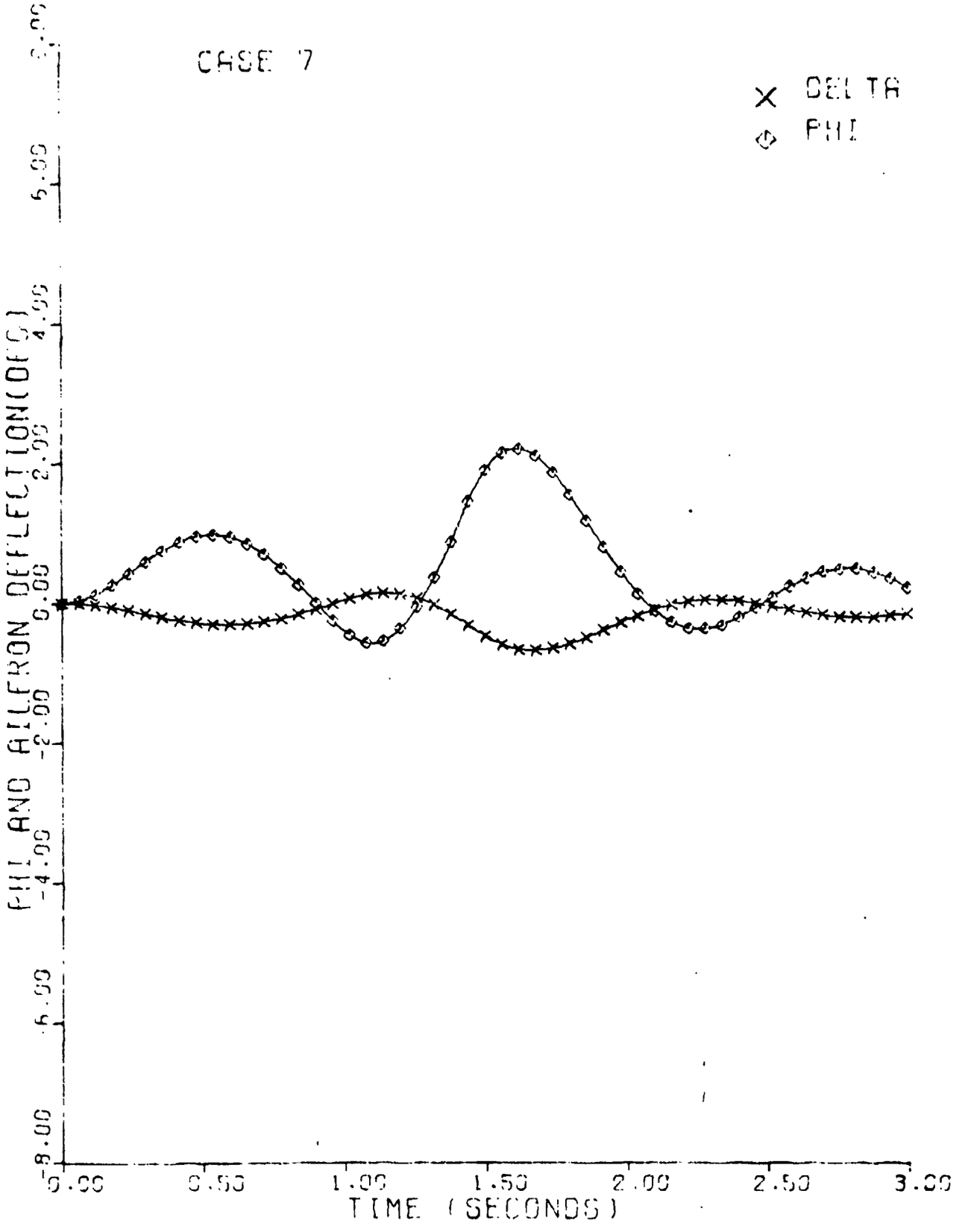

Figure 50. MQM-74C Roll Angle and Aileron Time History

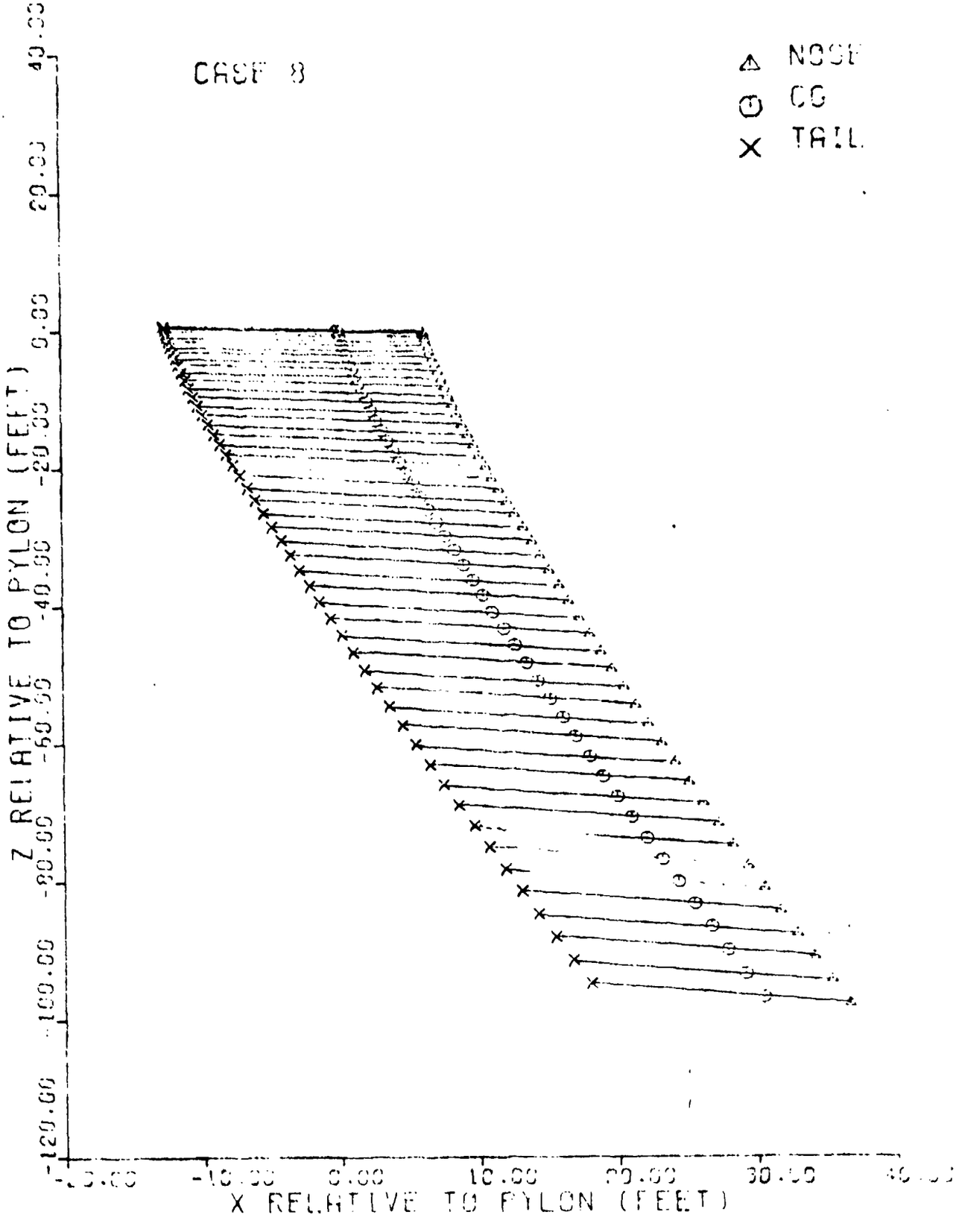

Figure 51. MQM-74C Longitudinal Separation Trajectory

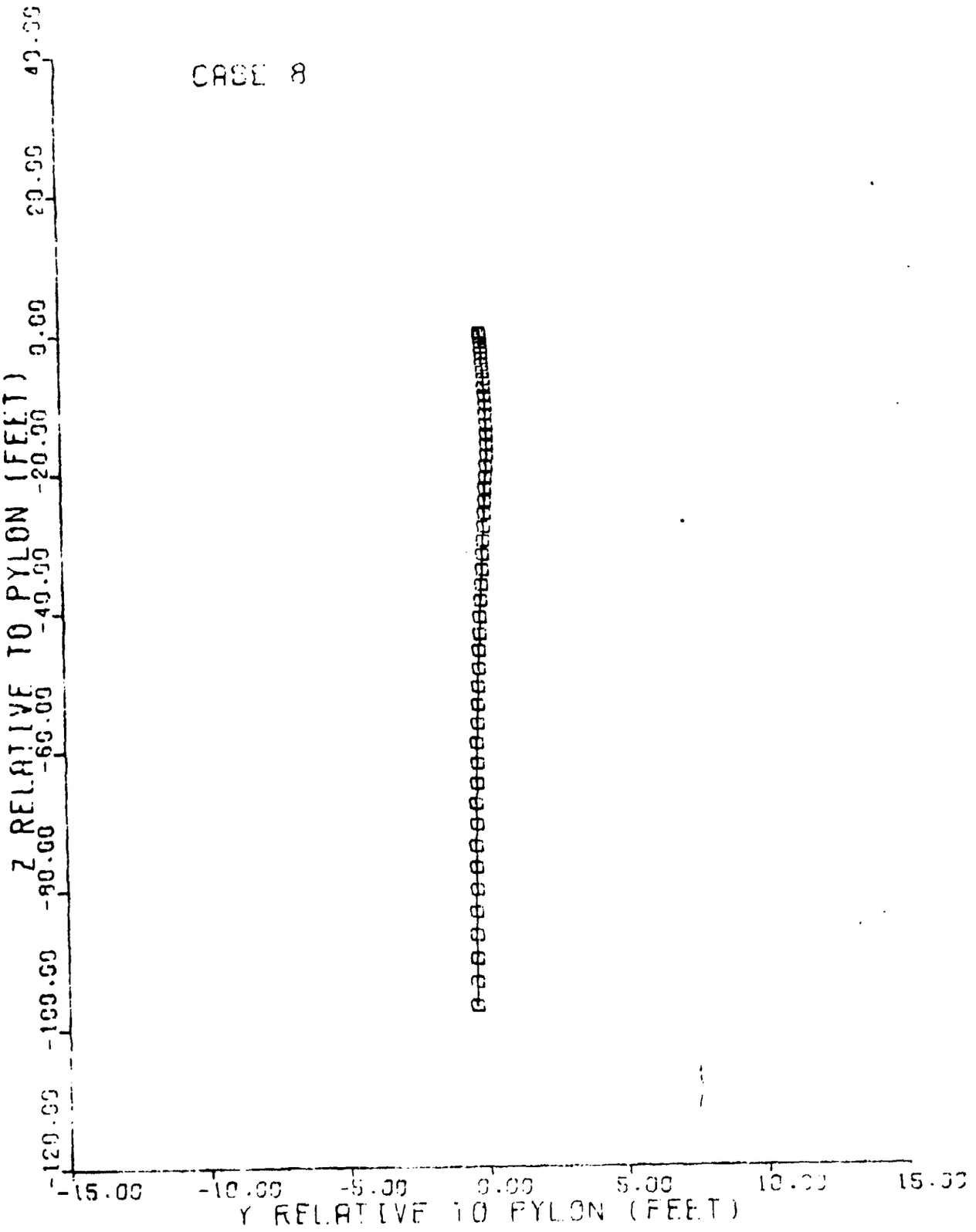

Figure 52. MQM-74C Lateral Separation Trajectory

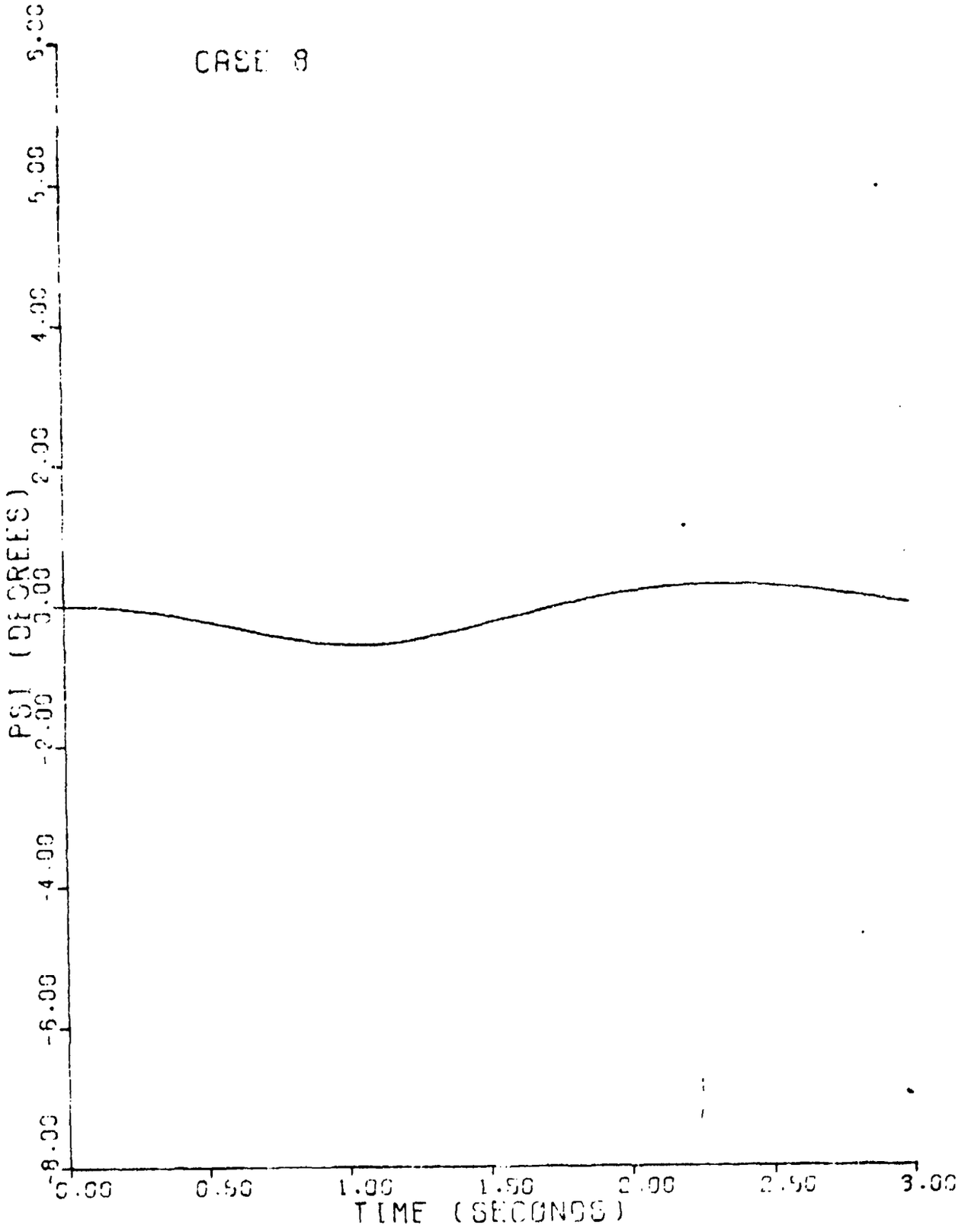

Figure 53. MQM-74C Yaw Time History

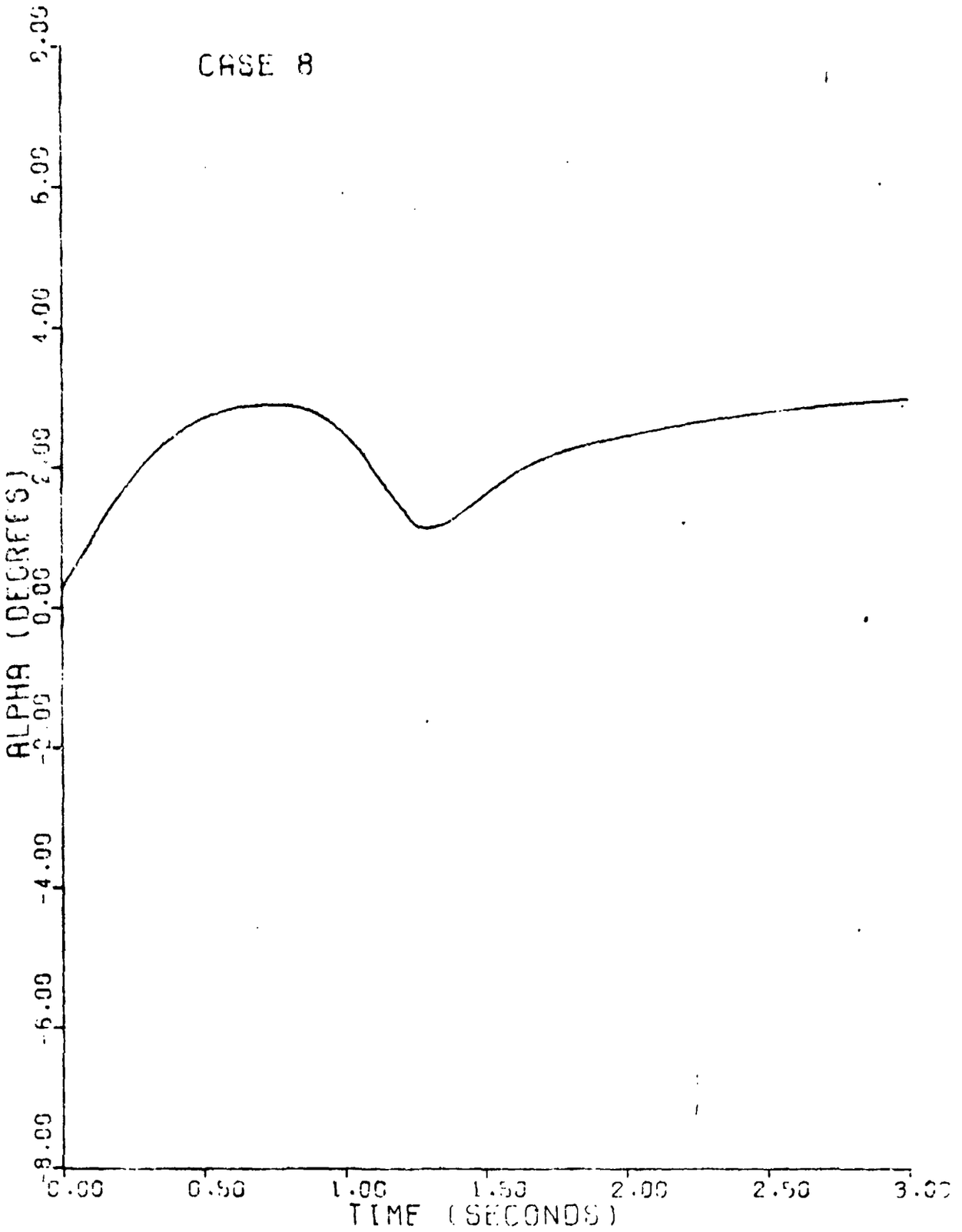

Figure 54. MQM-74C Angle of Attack Time History

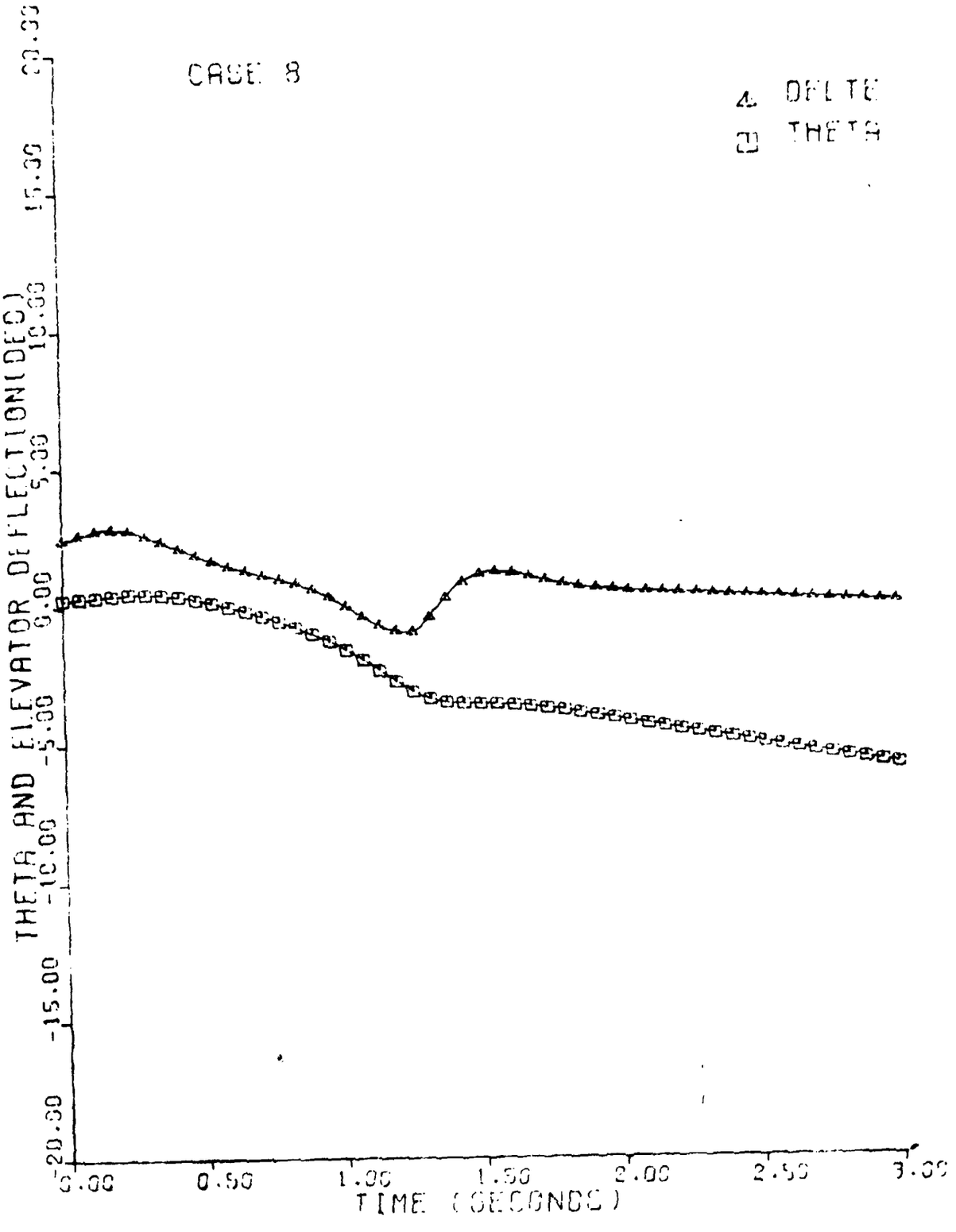

Figure 55. MQM-74C Pitch Attitude and Elevator Deflection Time History

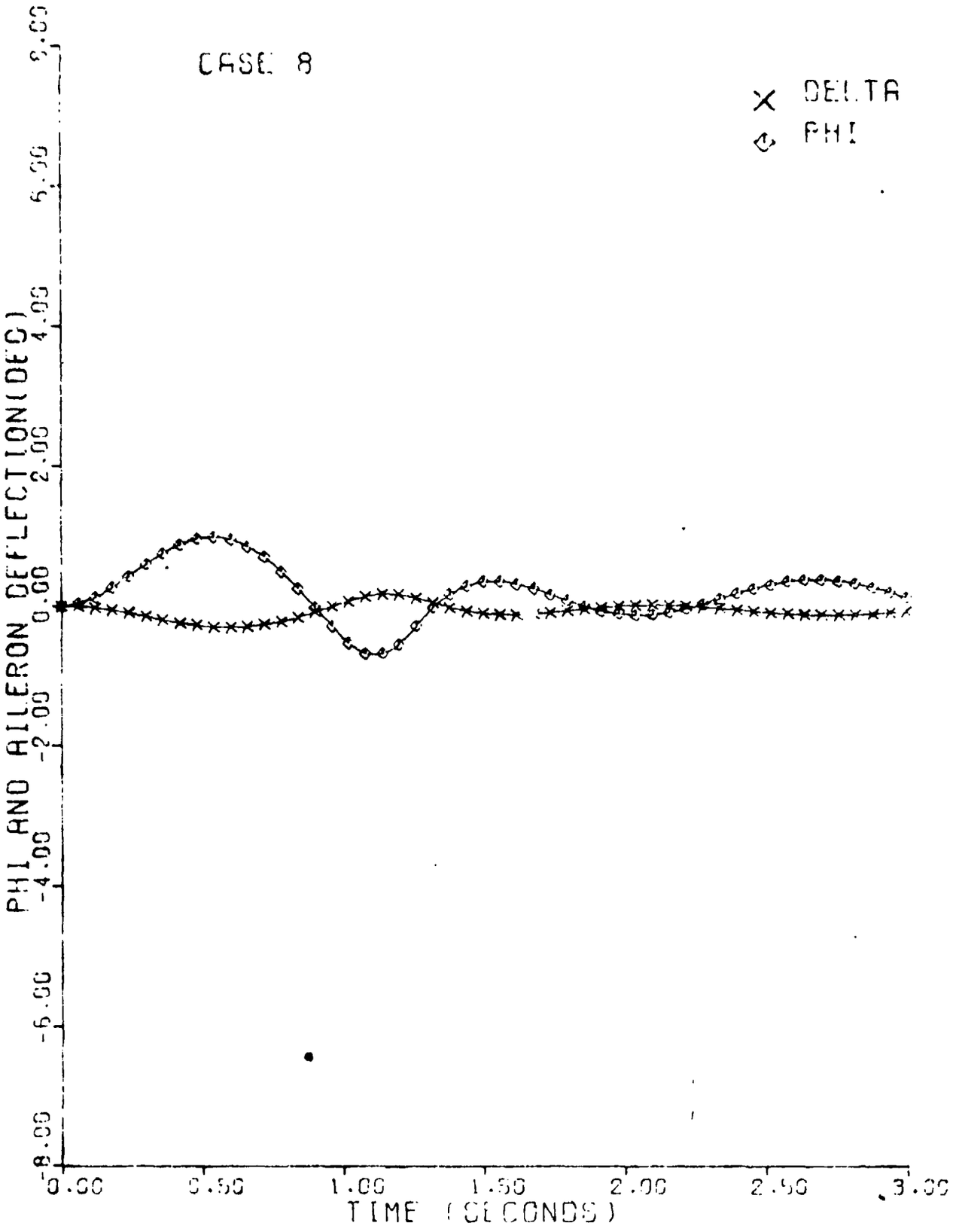

Figure 56. MQM-74C Roll Angle and Aileron Time History

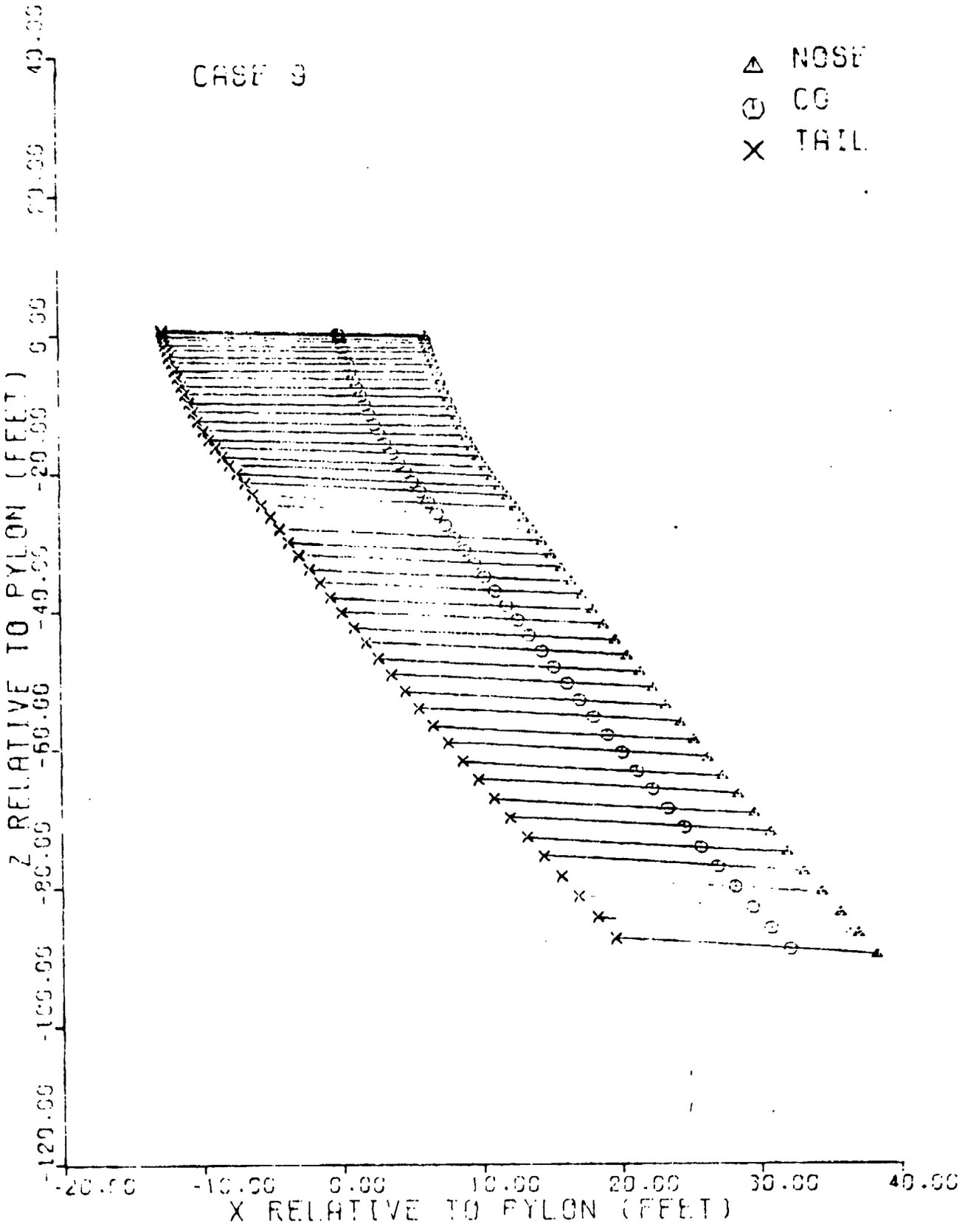

Figure 57. MQM-74C Longitudinal Separation Trajectory

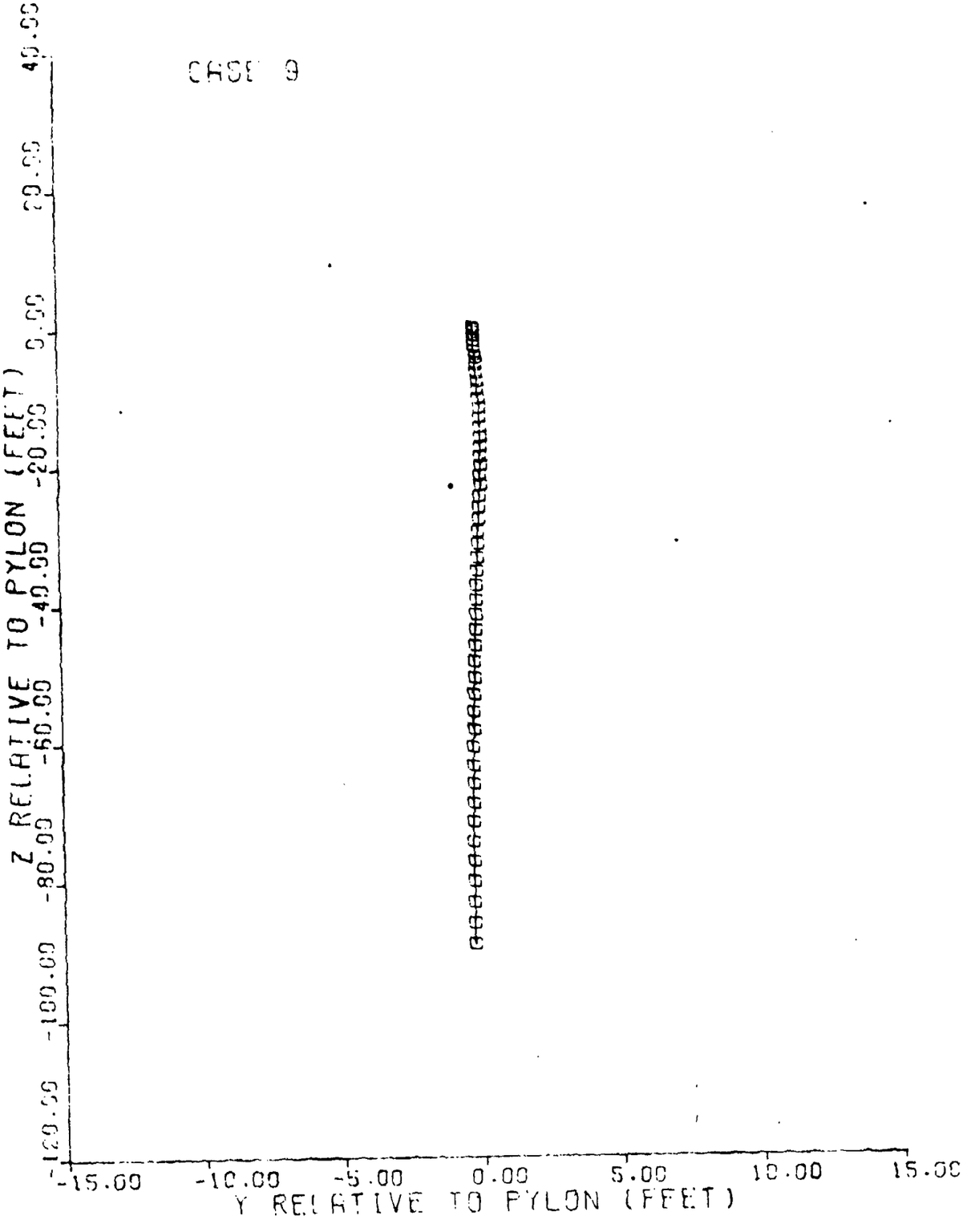

Figure 58. MQM-74C Lateral Separation Trajectory

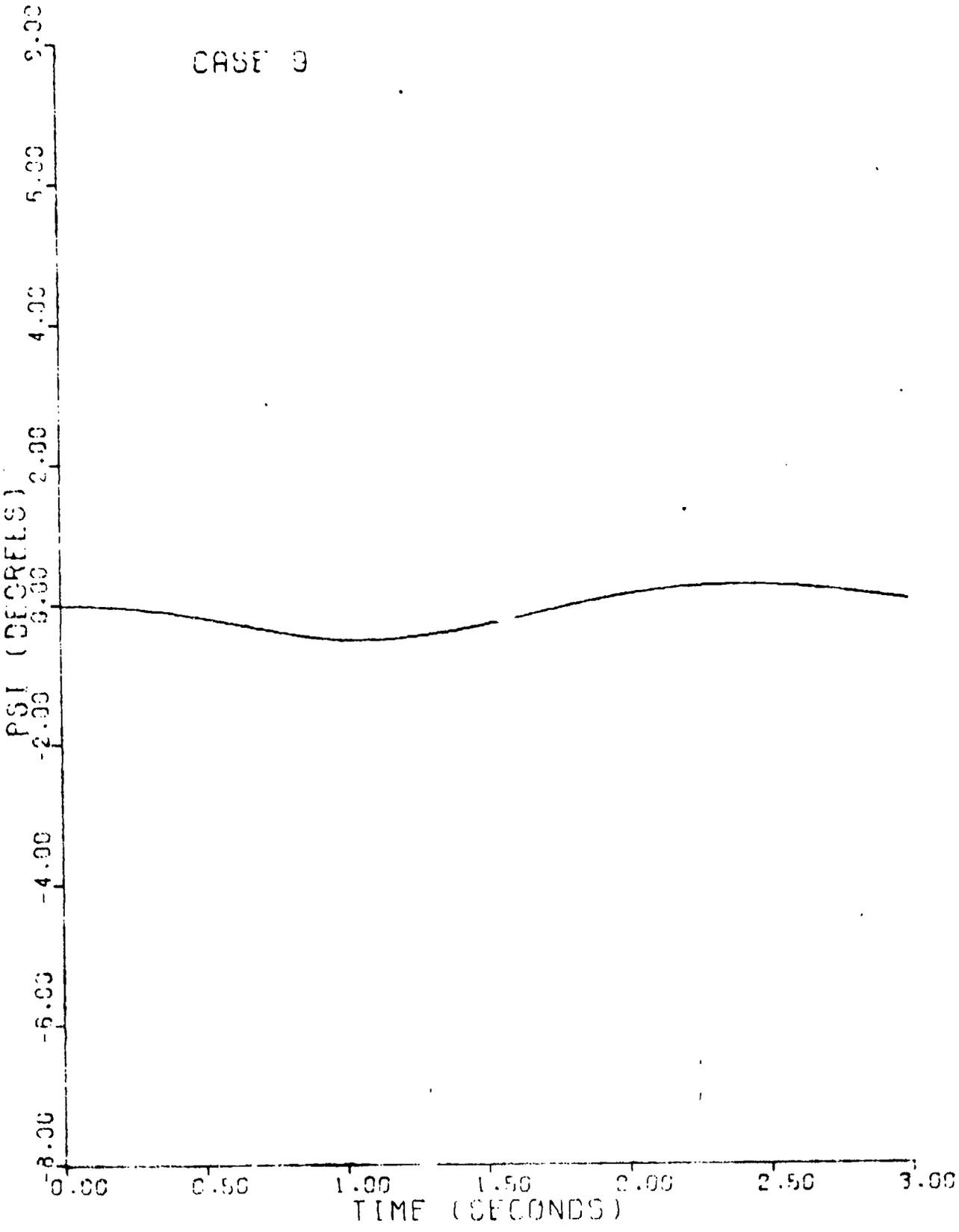

Figure 59. MQM-74C Yaw Time History

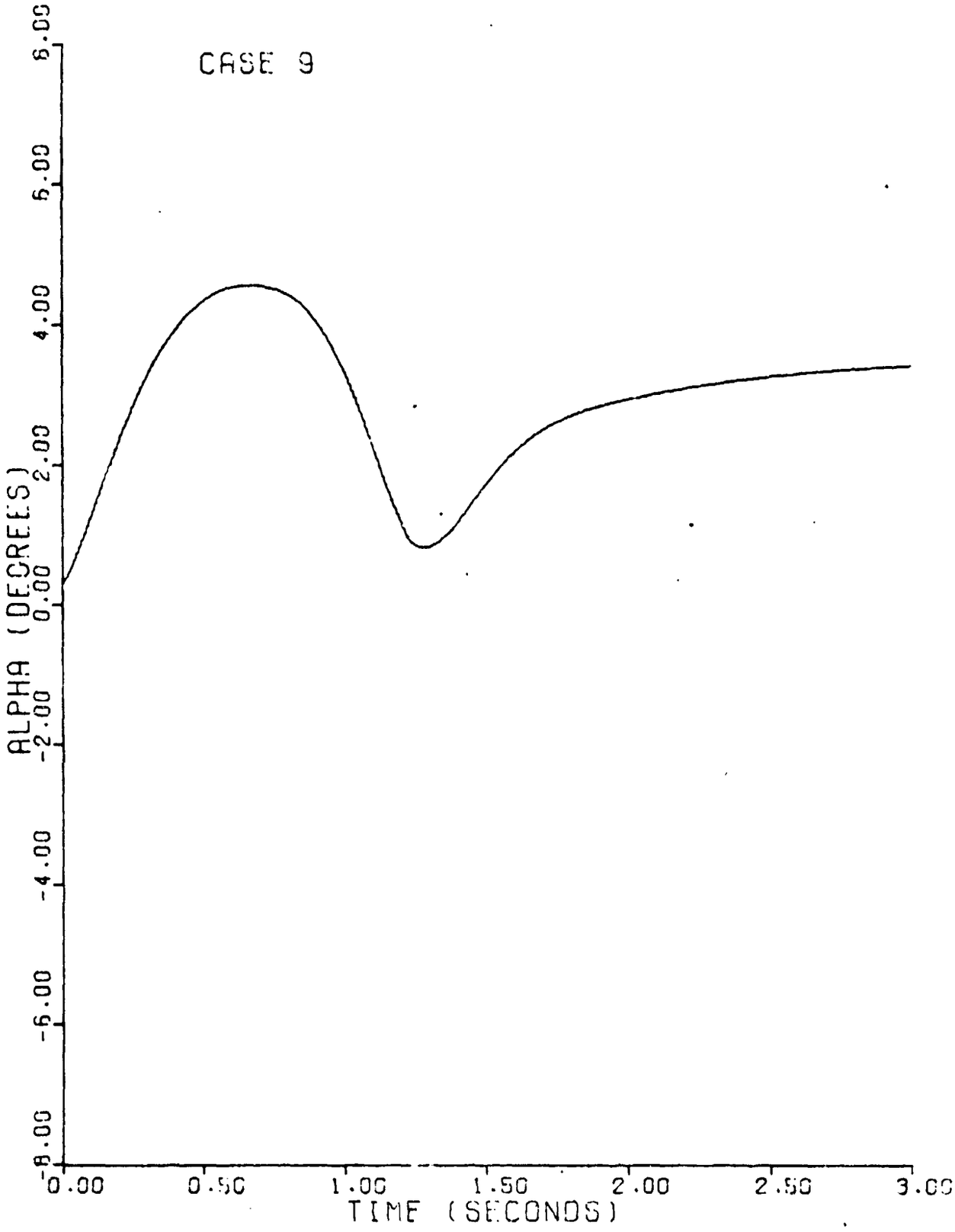

Figure 60. MQM-74C Angle of Attack Time History

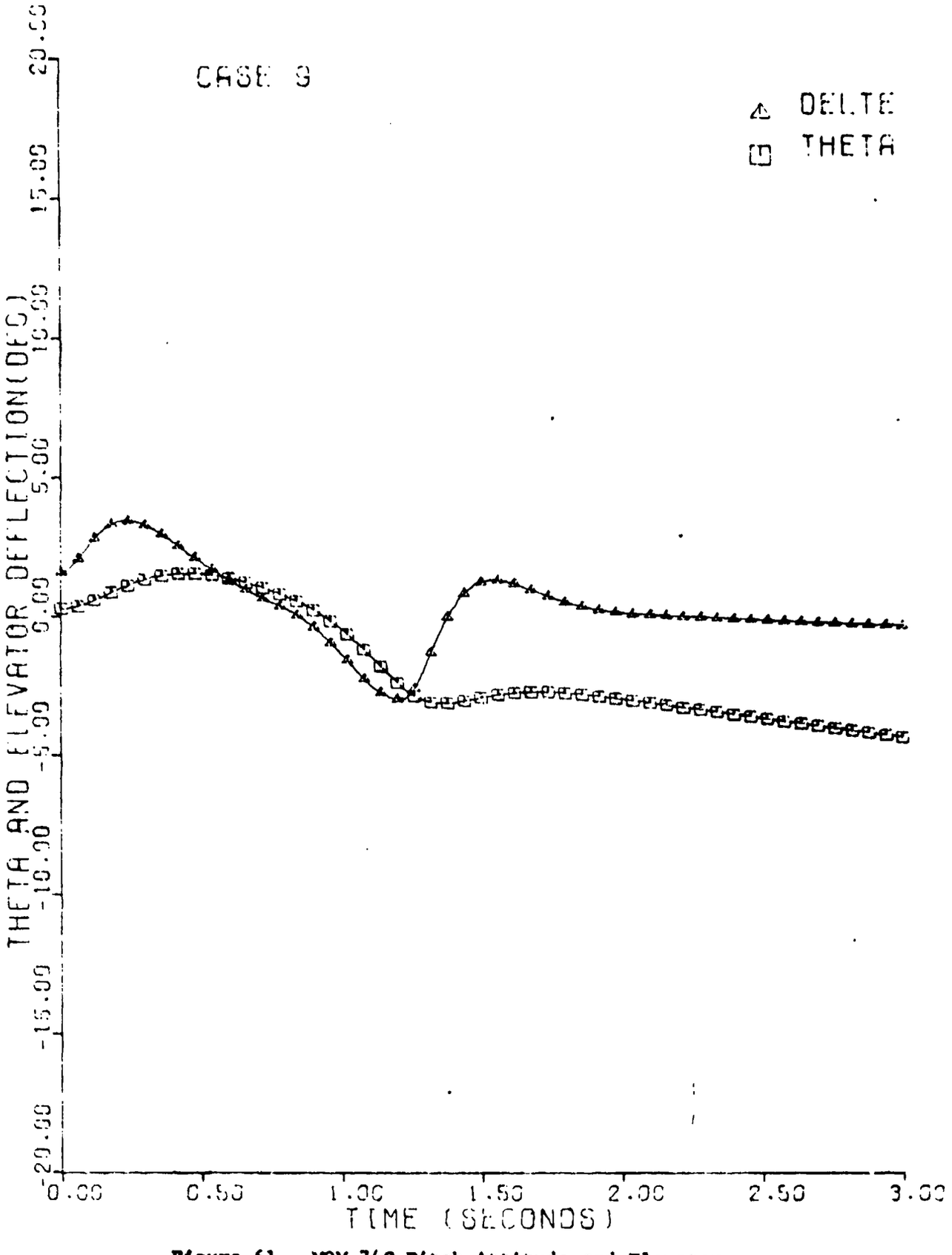

Figure 61. MQM-74C Pitch Attitude and Elevator Deflection Time History

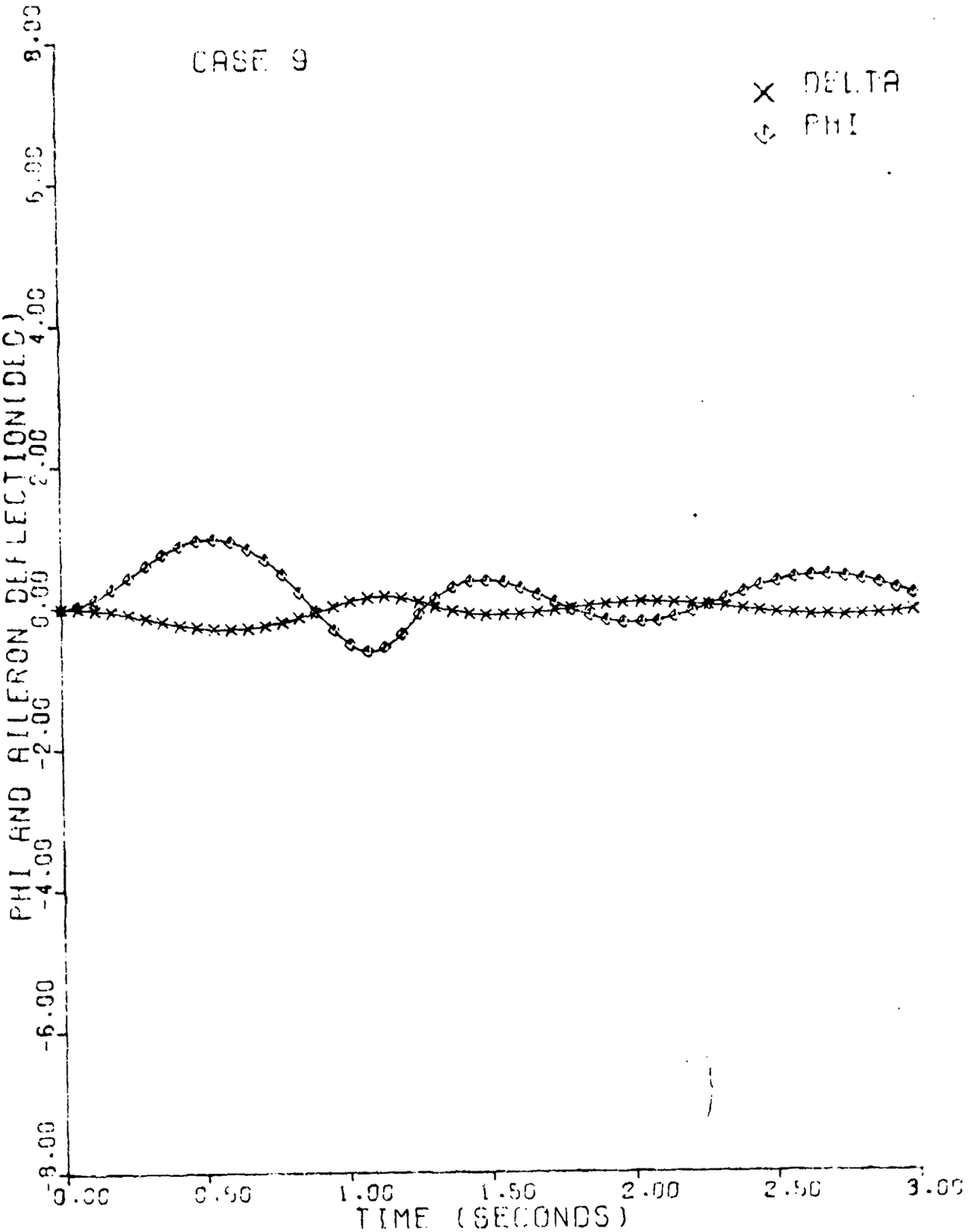

Figure 62. MQM-74C Roll Angle and Aileron Time History

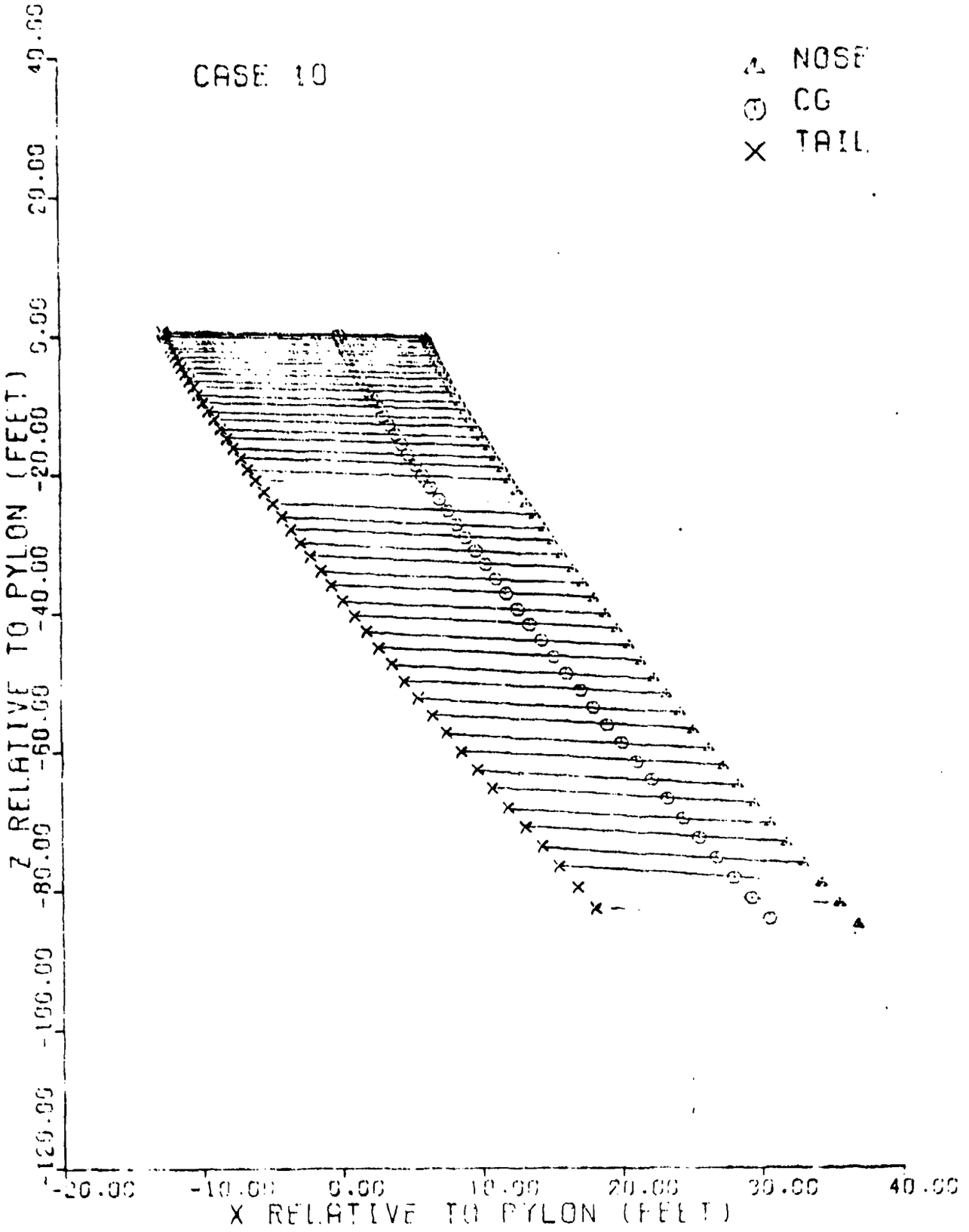

Figure 63. MQM-74C Longitudinal Separation Trajectory

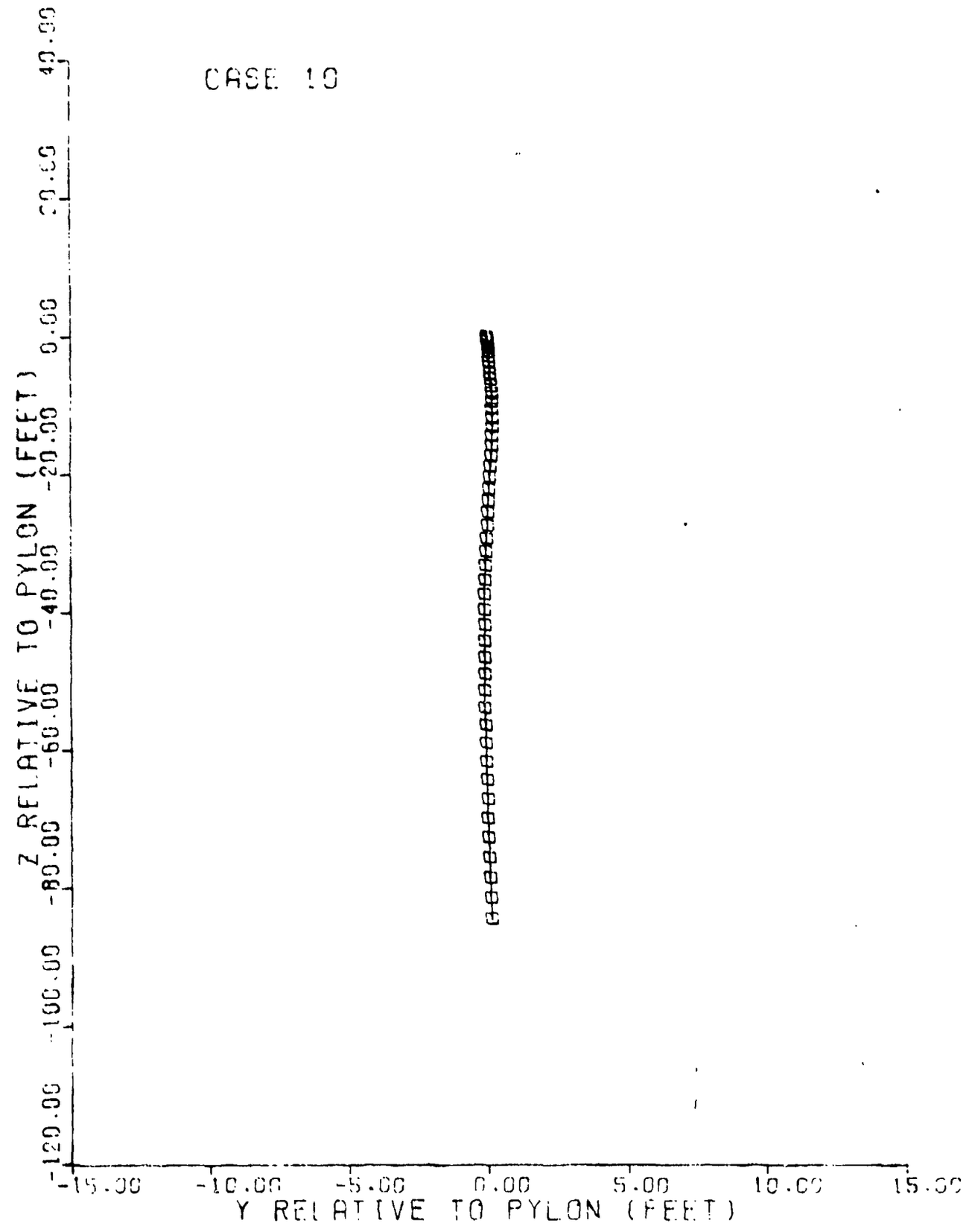

Figure 64. MQM-74C Lateral Separation Trajectory

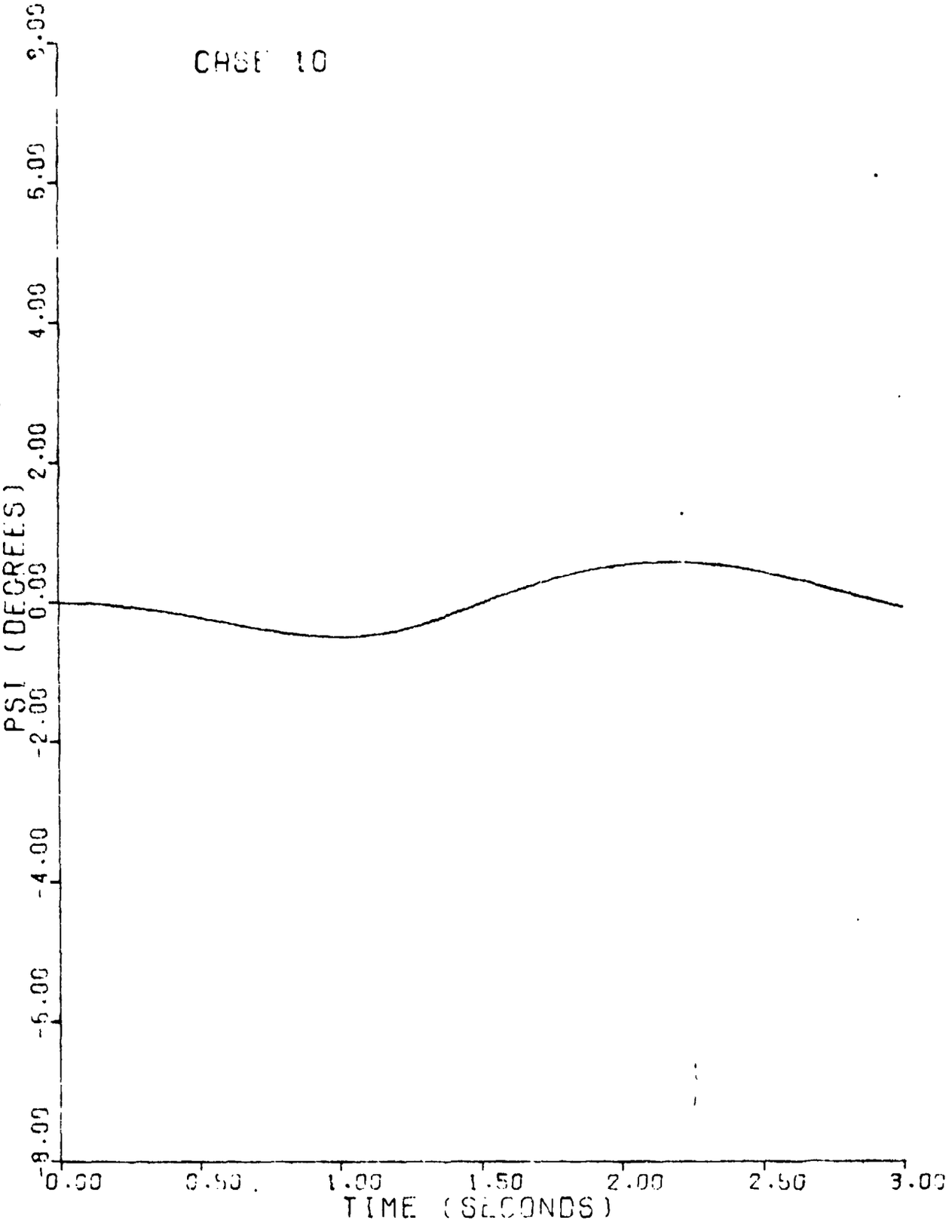

Figure 65. MQM-74C Yaw Time History

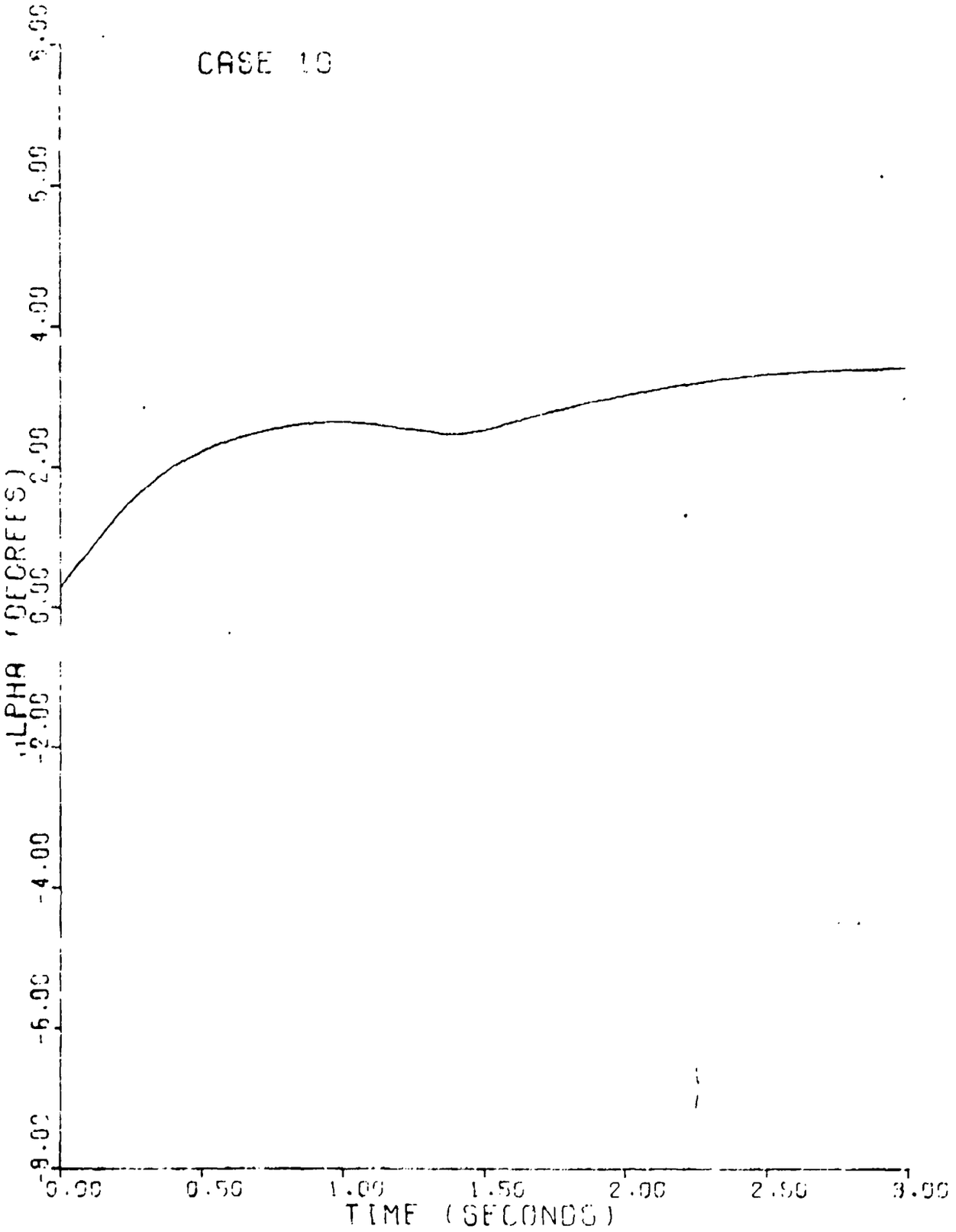

Figure 66. MQM-/4C Angle of Attack Time History

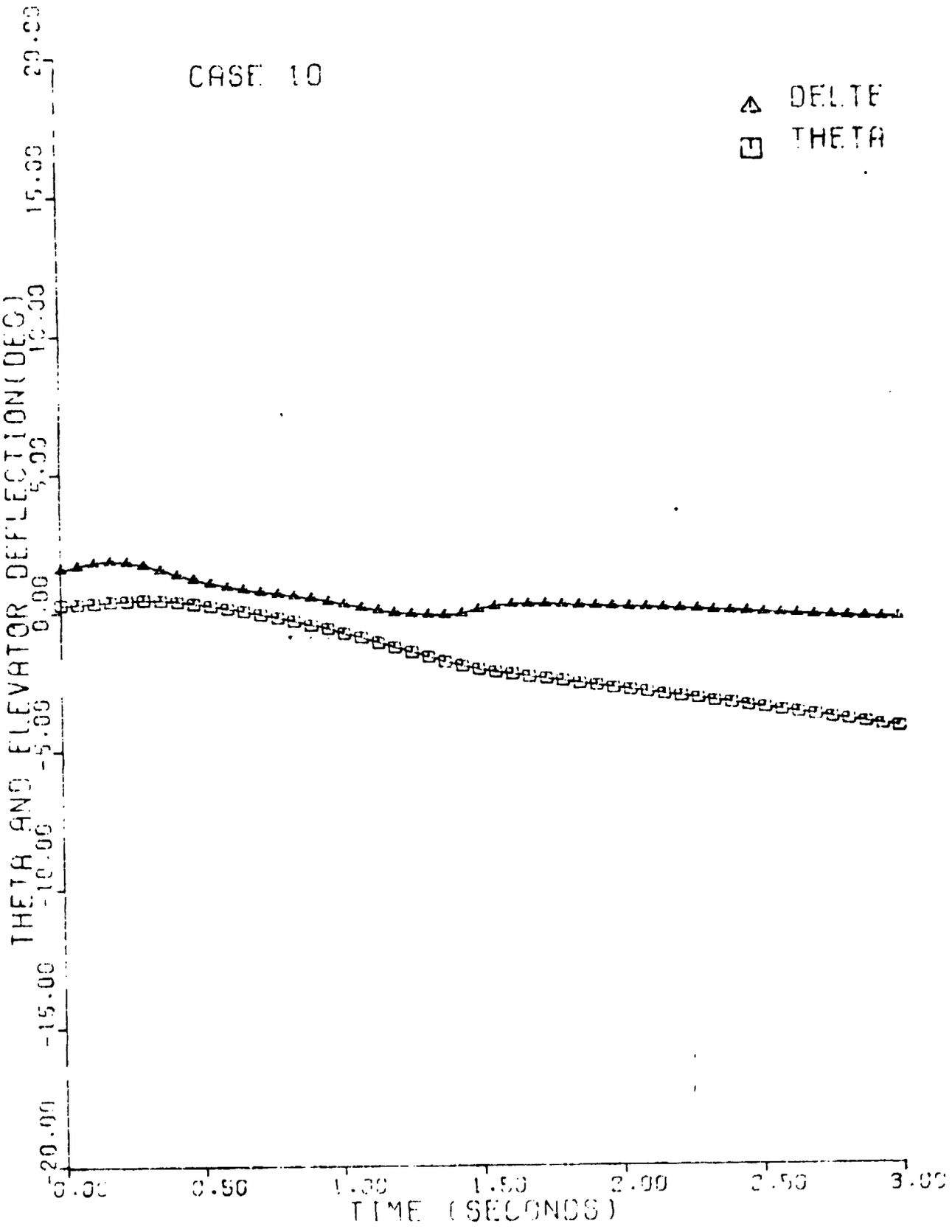

Figure 67. MQM-74C Pitch Attitude and Elevator Deflection Time History

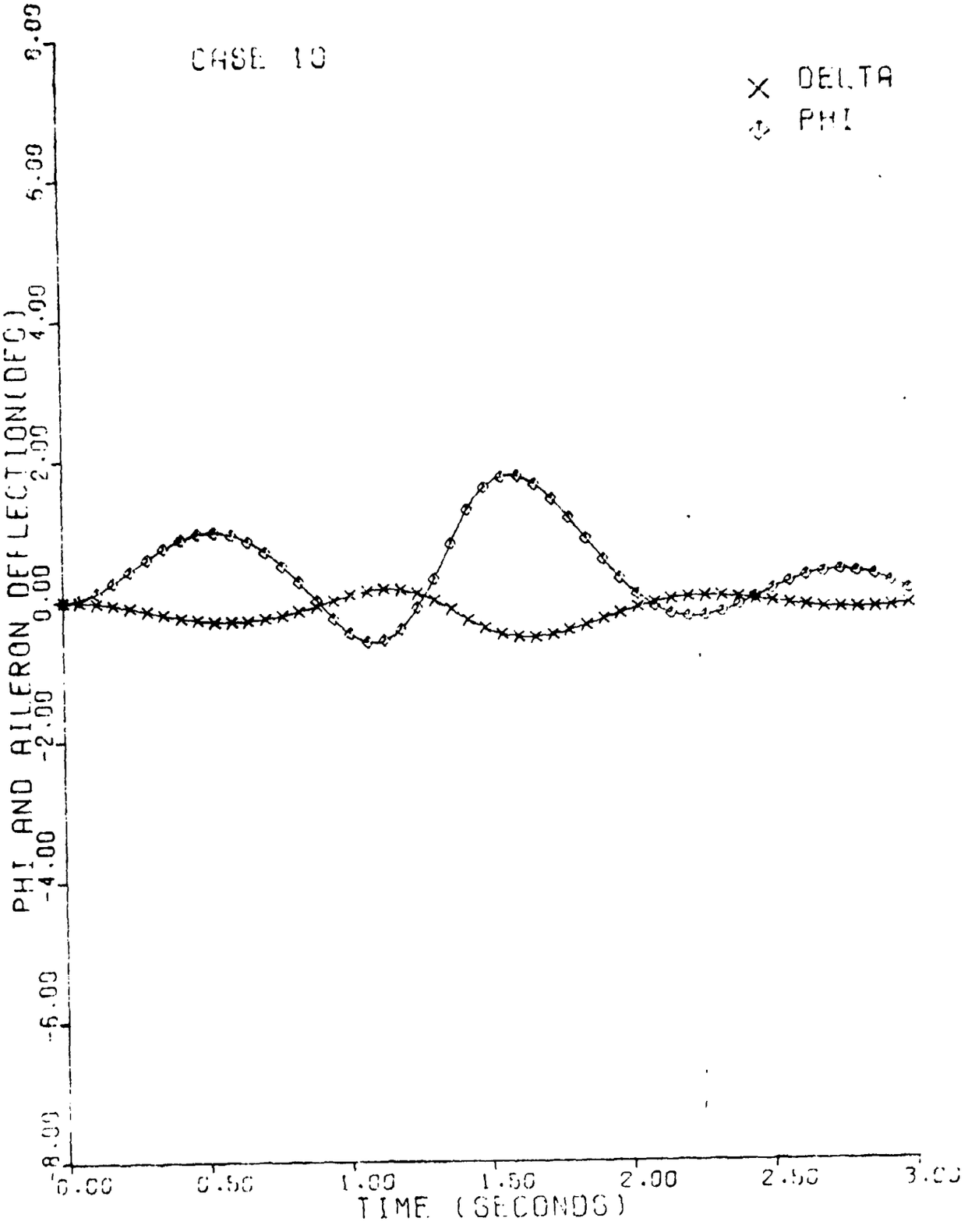

Figure 68. MQM-74C Roll Angle and Aileron Time History

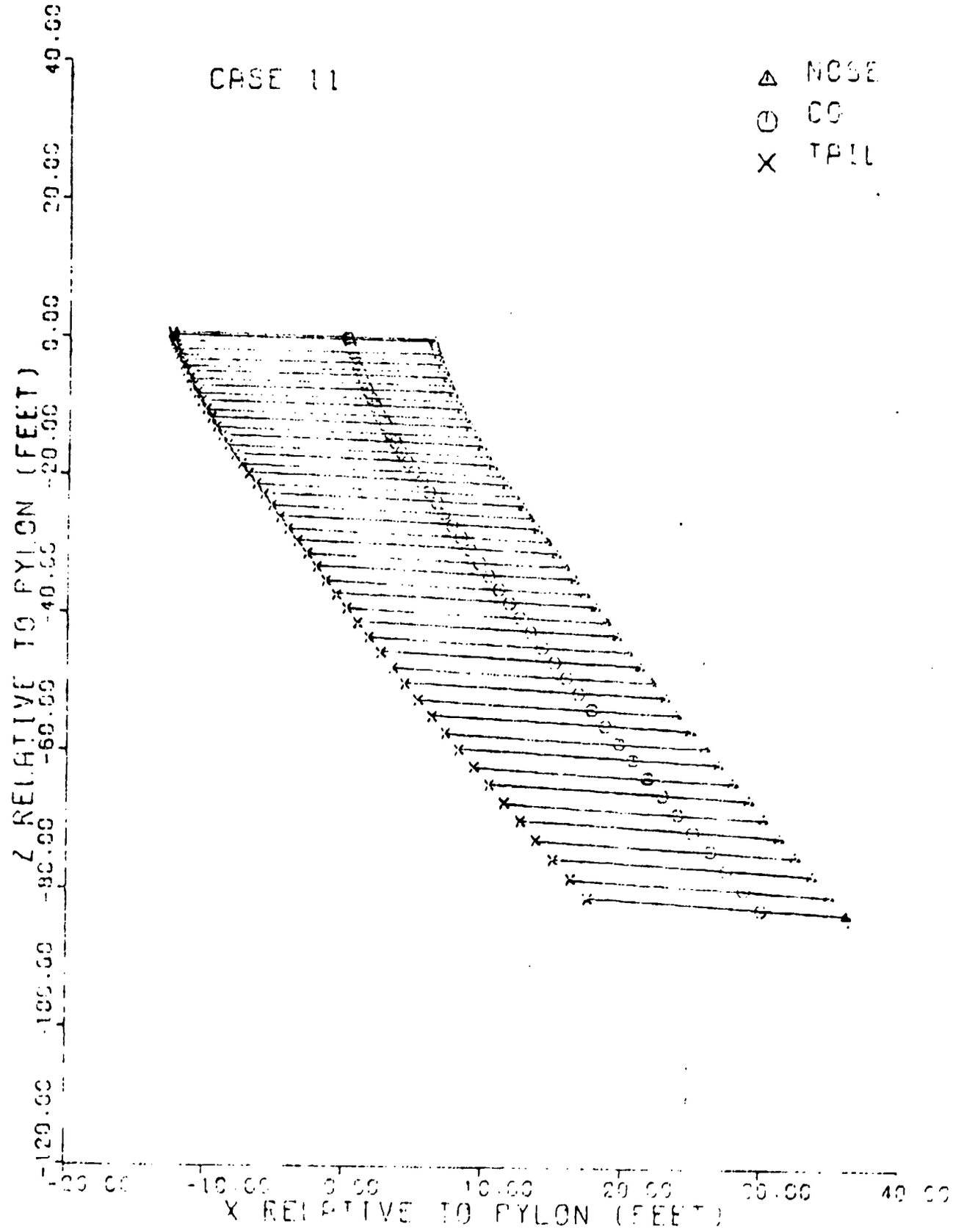

Figure 69. MQM-74C Longitudinal Separation Trajectory

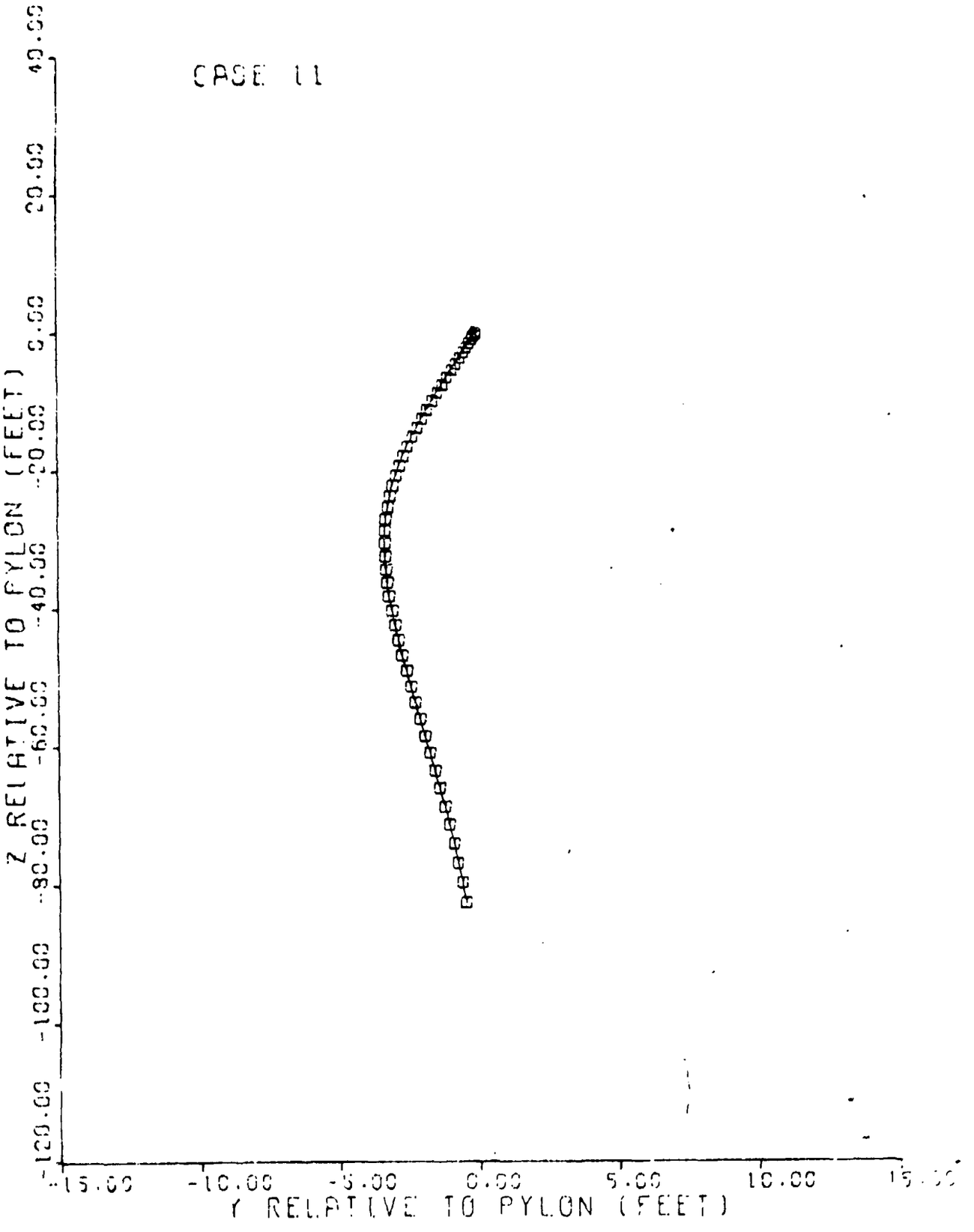

Figure 70. MQM-74C Lateral Separation Trajectory

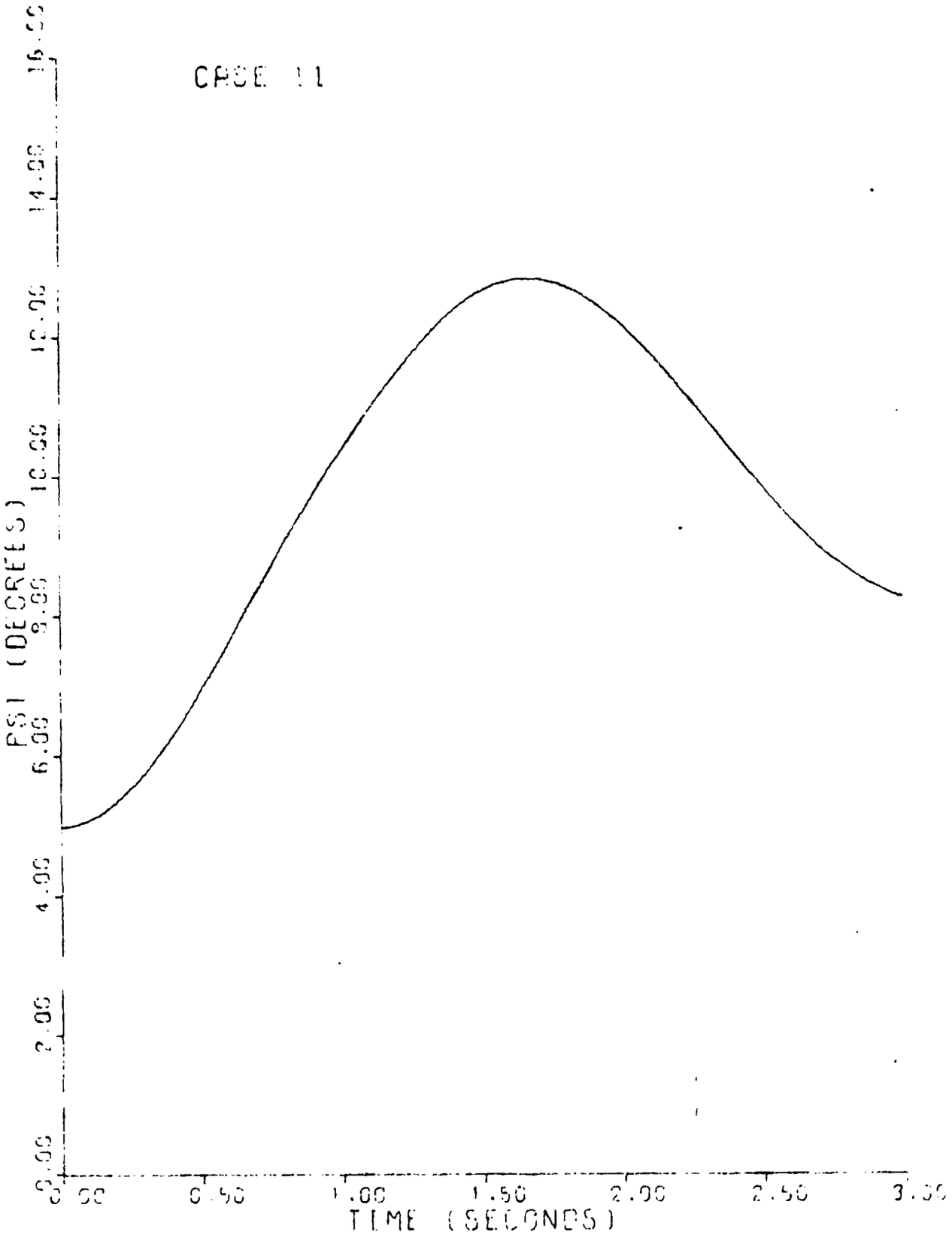

Figure 71. MQM-74C Yaw Time History

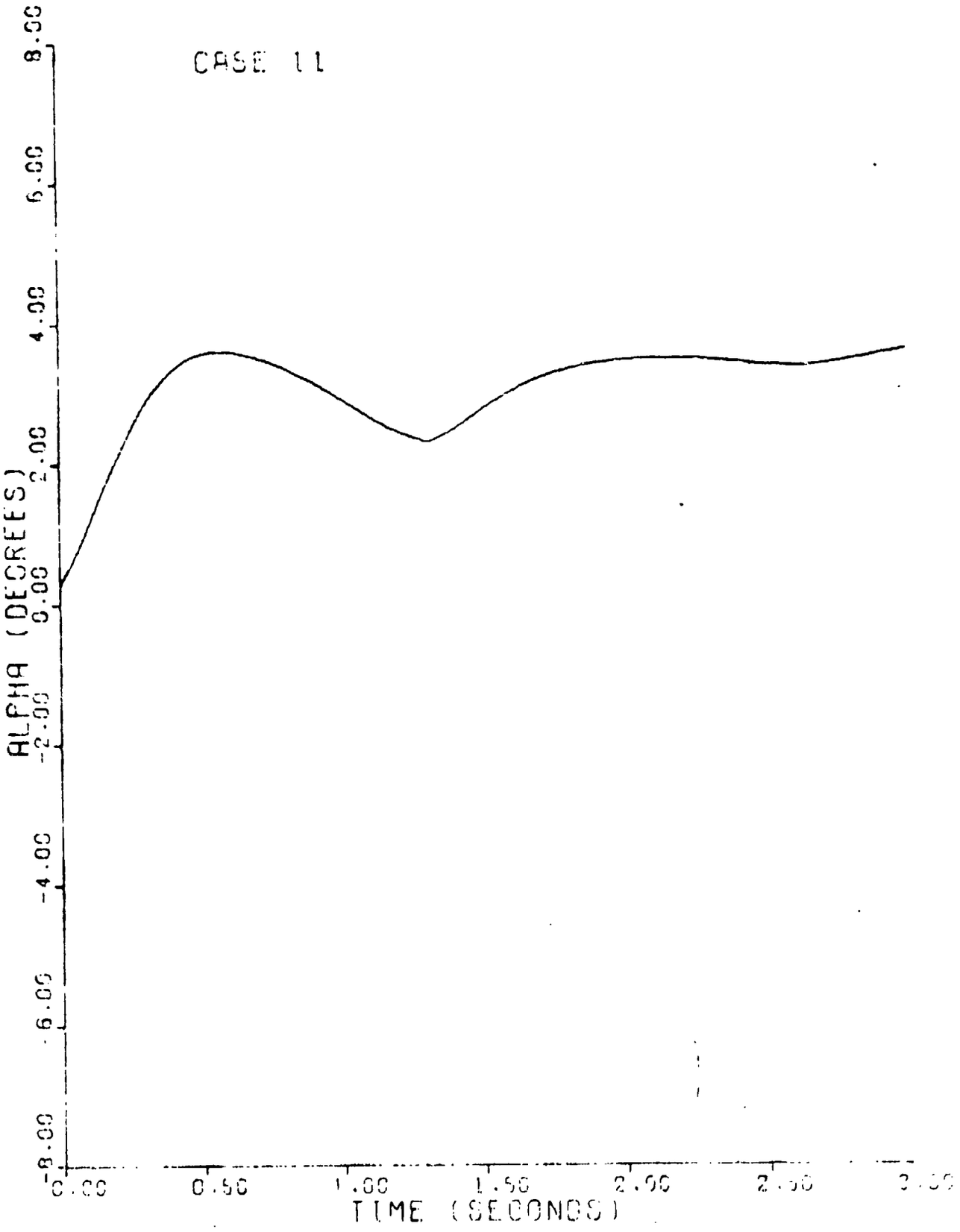

Figure 72. MQM-74C Angle of Attack Time History

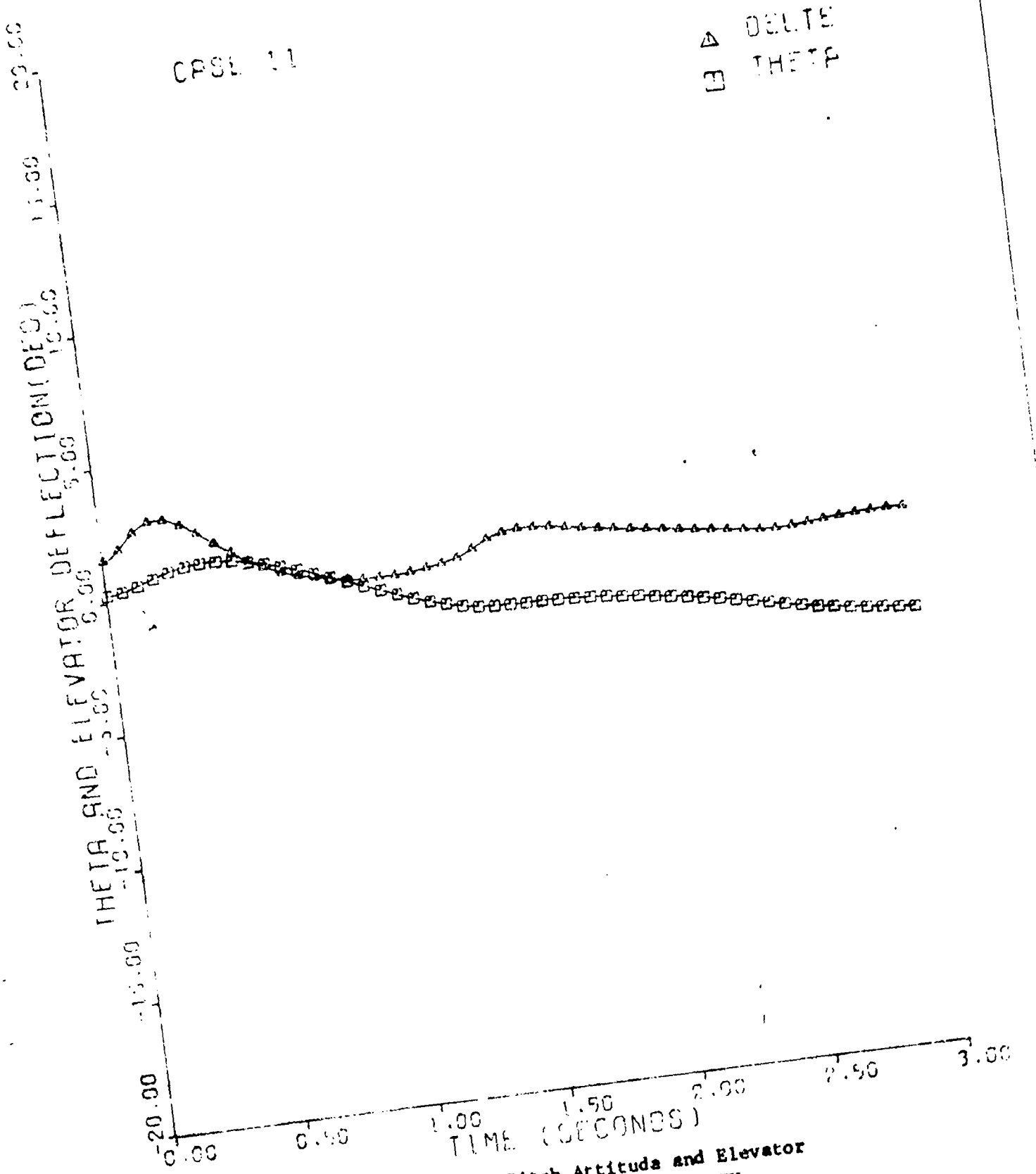

Figure 73. MQM-74C Pitch Attitude and Elevator Deflection Time History

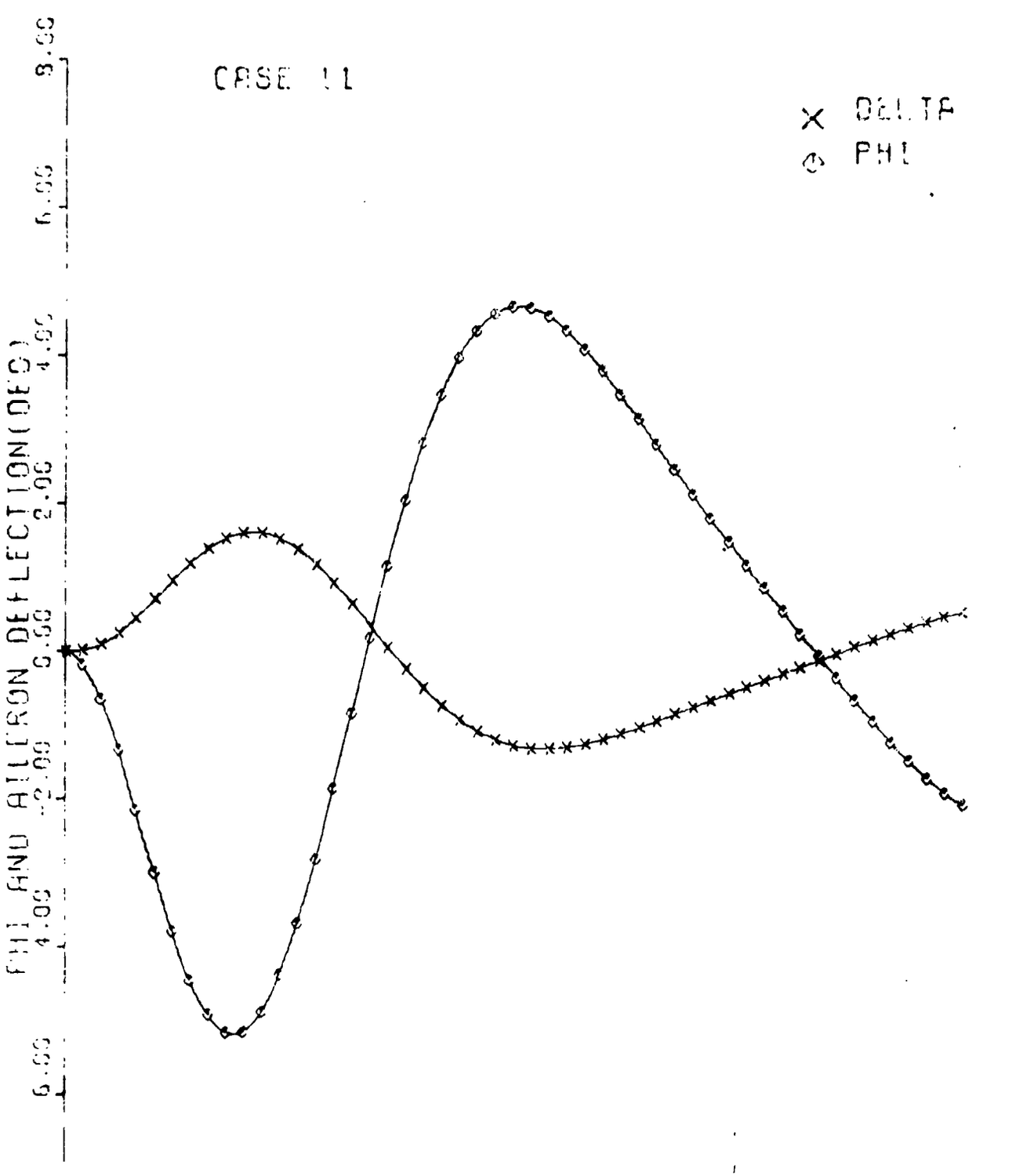

Figure 74. MQM-74C Roll Angle and Aileron Time History

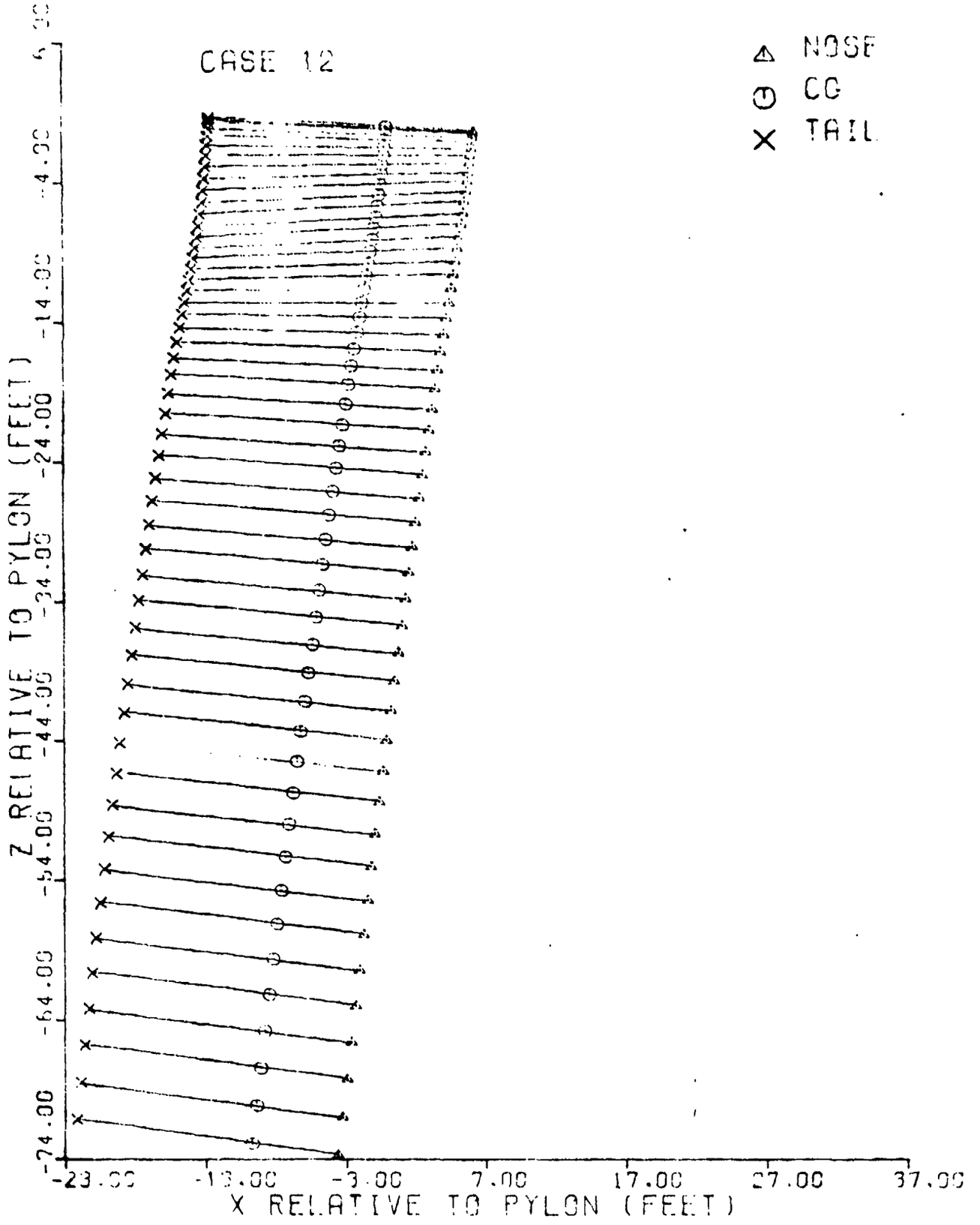

Figure 75. MQM-74C Longitudinal Separation Trajectory

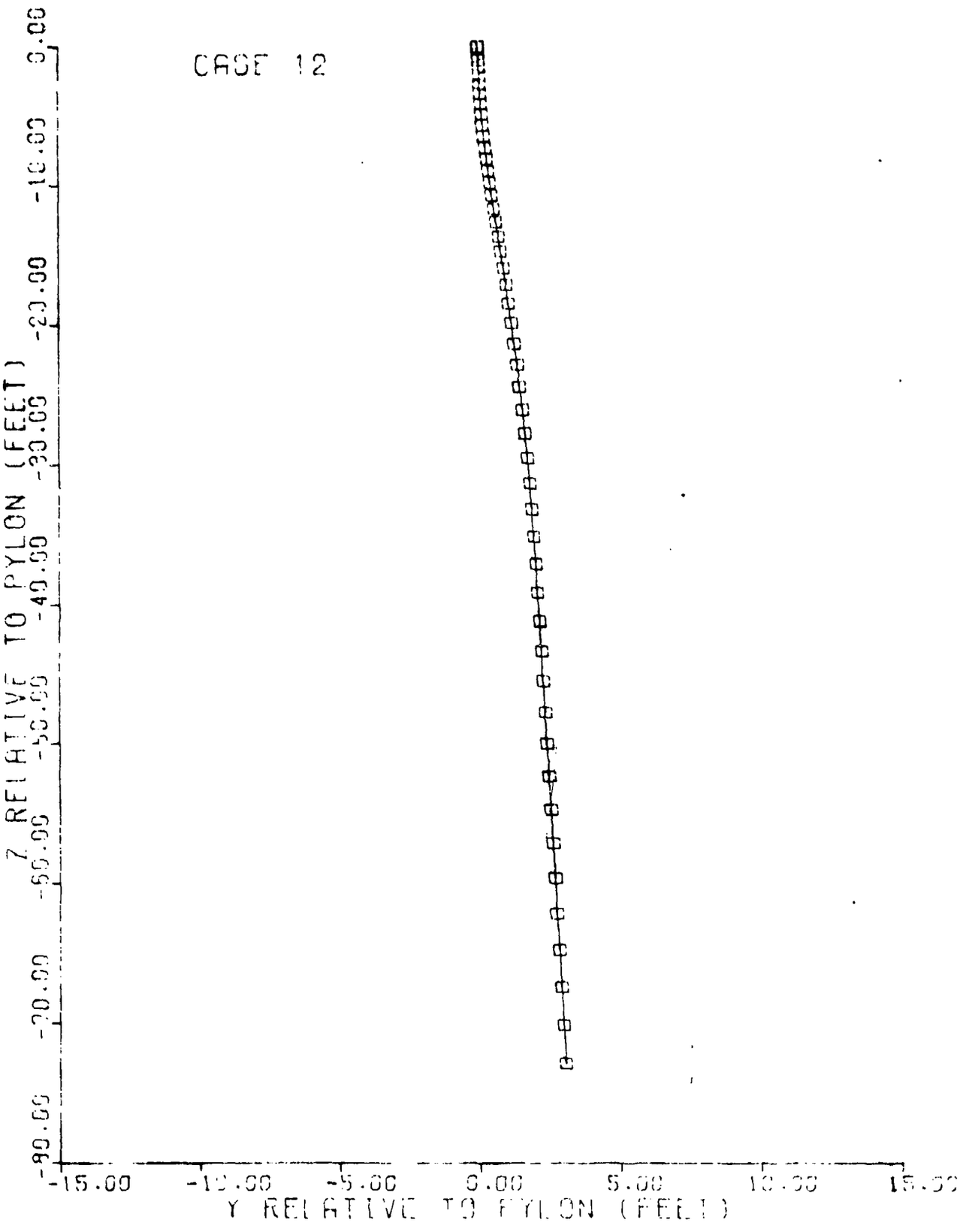

Figure 76. MQM-74C Lateral Separation Trajectory

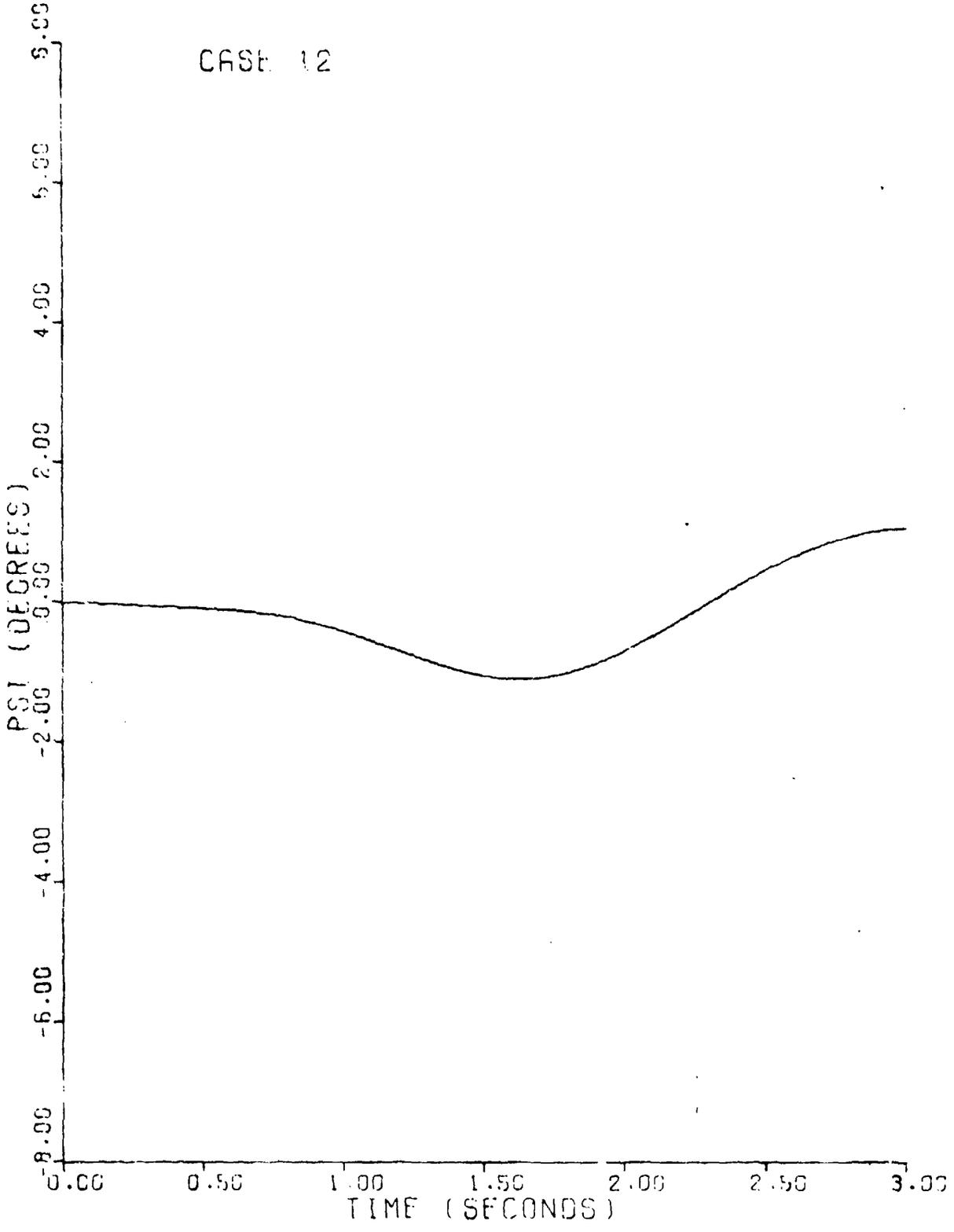

Figure 77. MQM-74C Yaw Time History

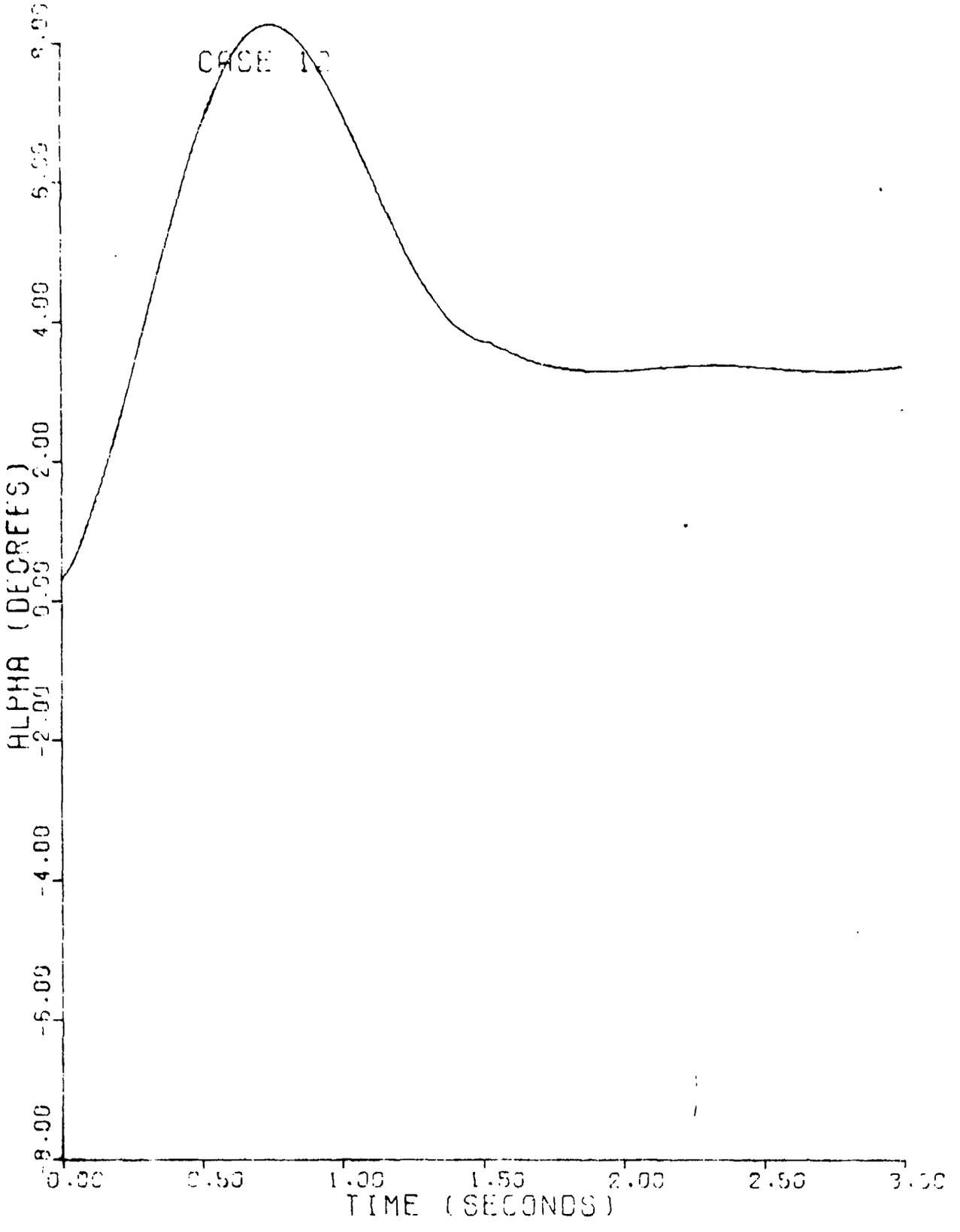

Figure 78. MQM-74C Angle of Attack Time History

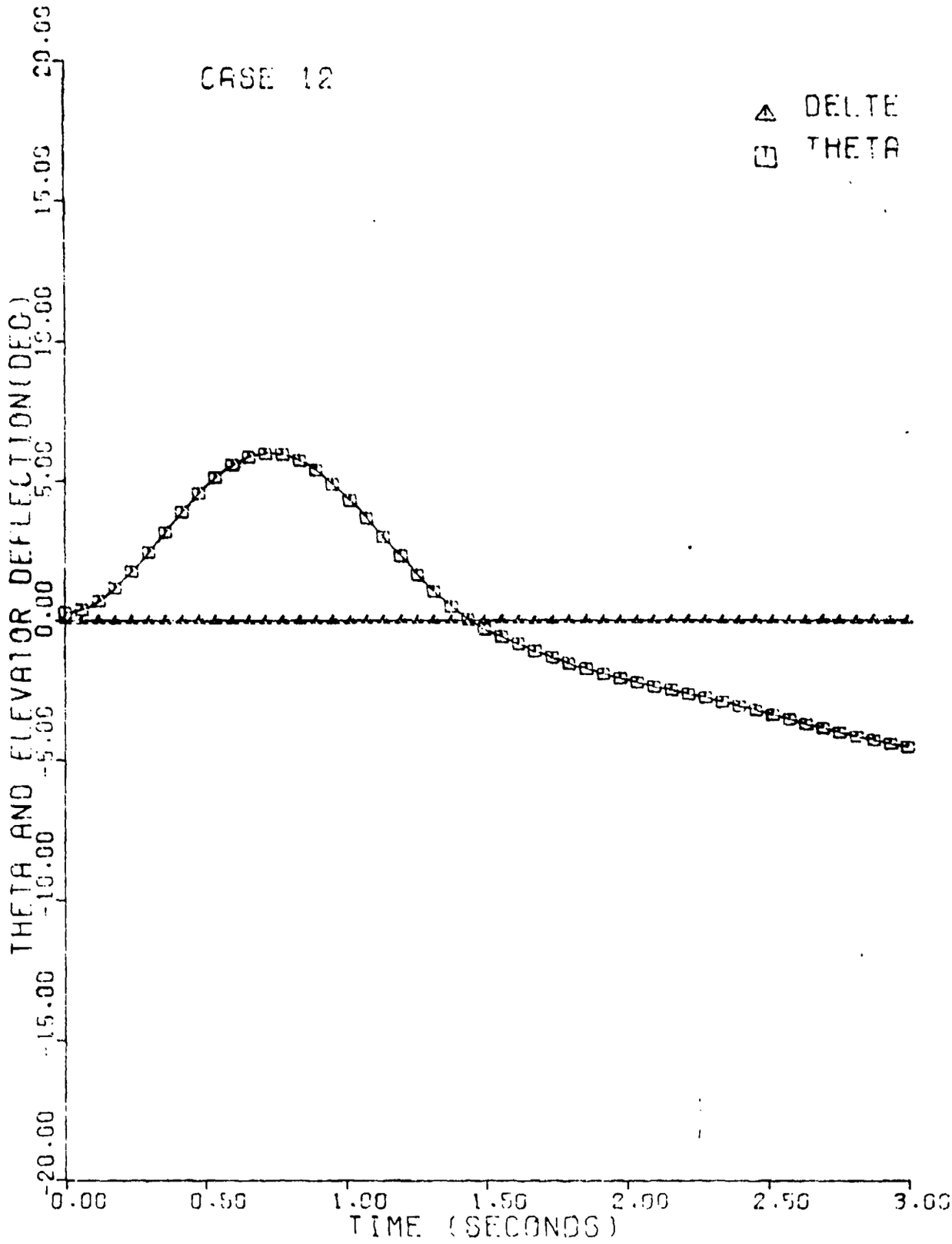

Figure 79. MQM-74C Pitch Attitude and Elevator Deflection Time History

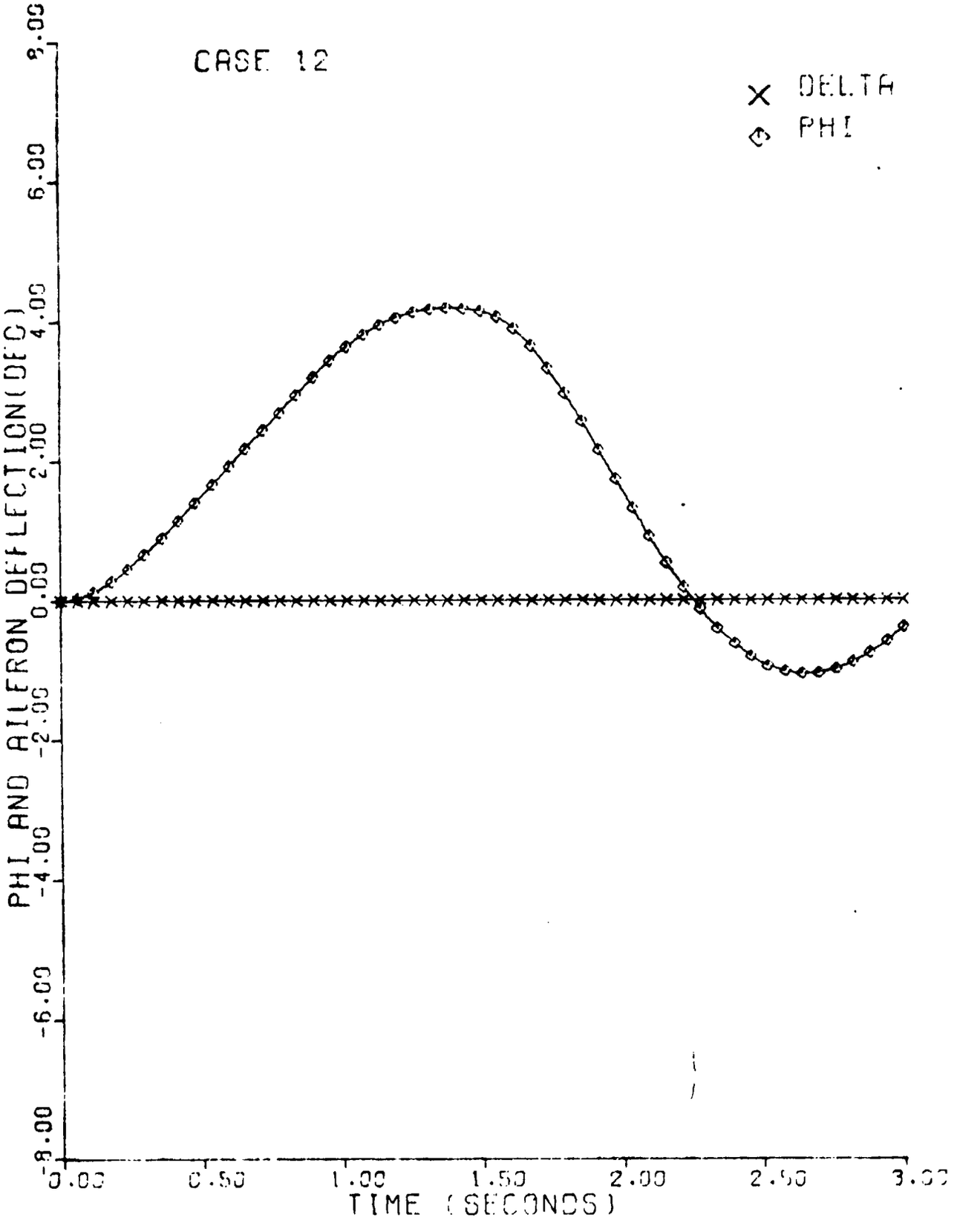

Figure 80. MQM-74C Roll Angle and Aileron Time History

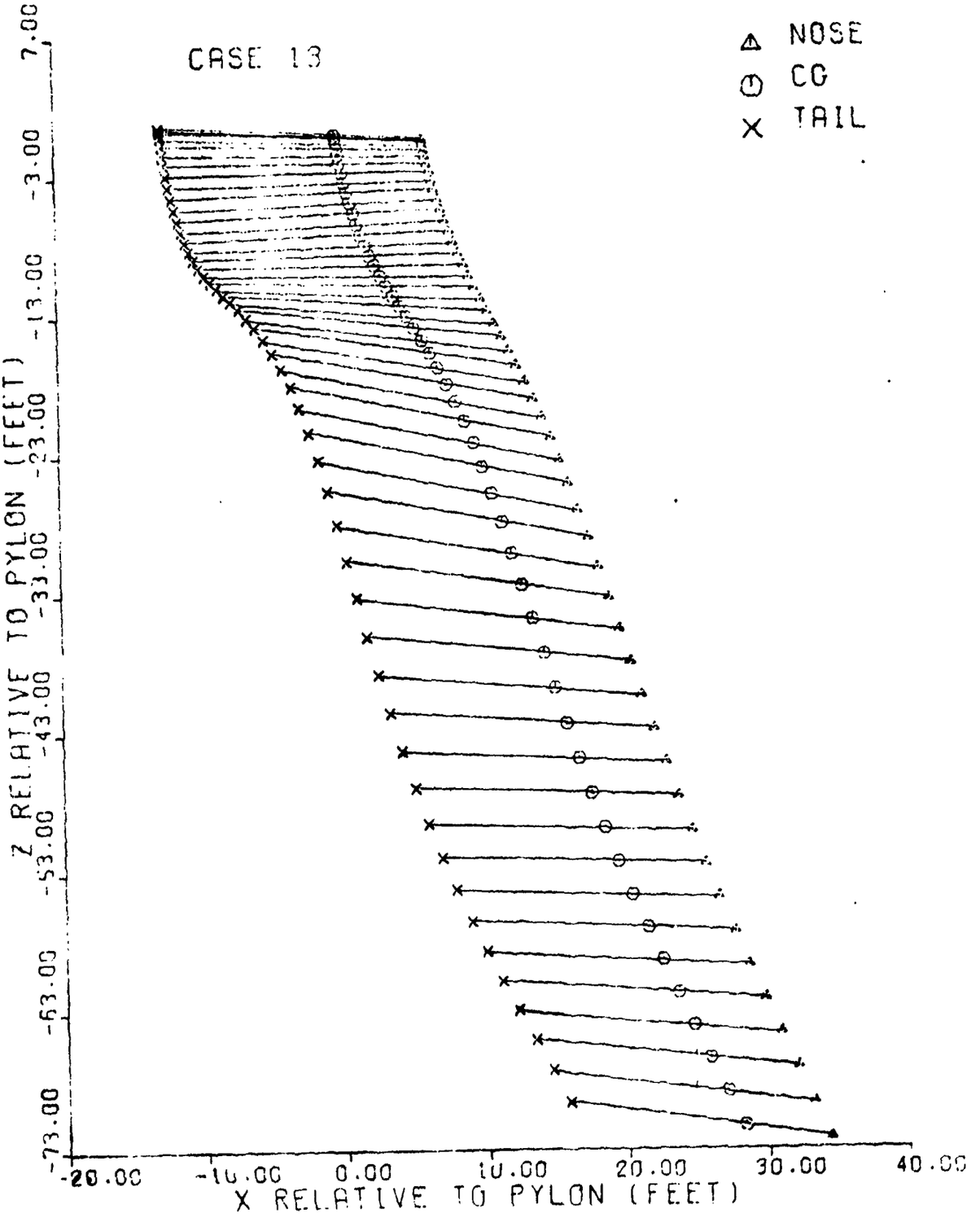

Figure 81. MQM-74C Longitudinal Separation Trajectory

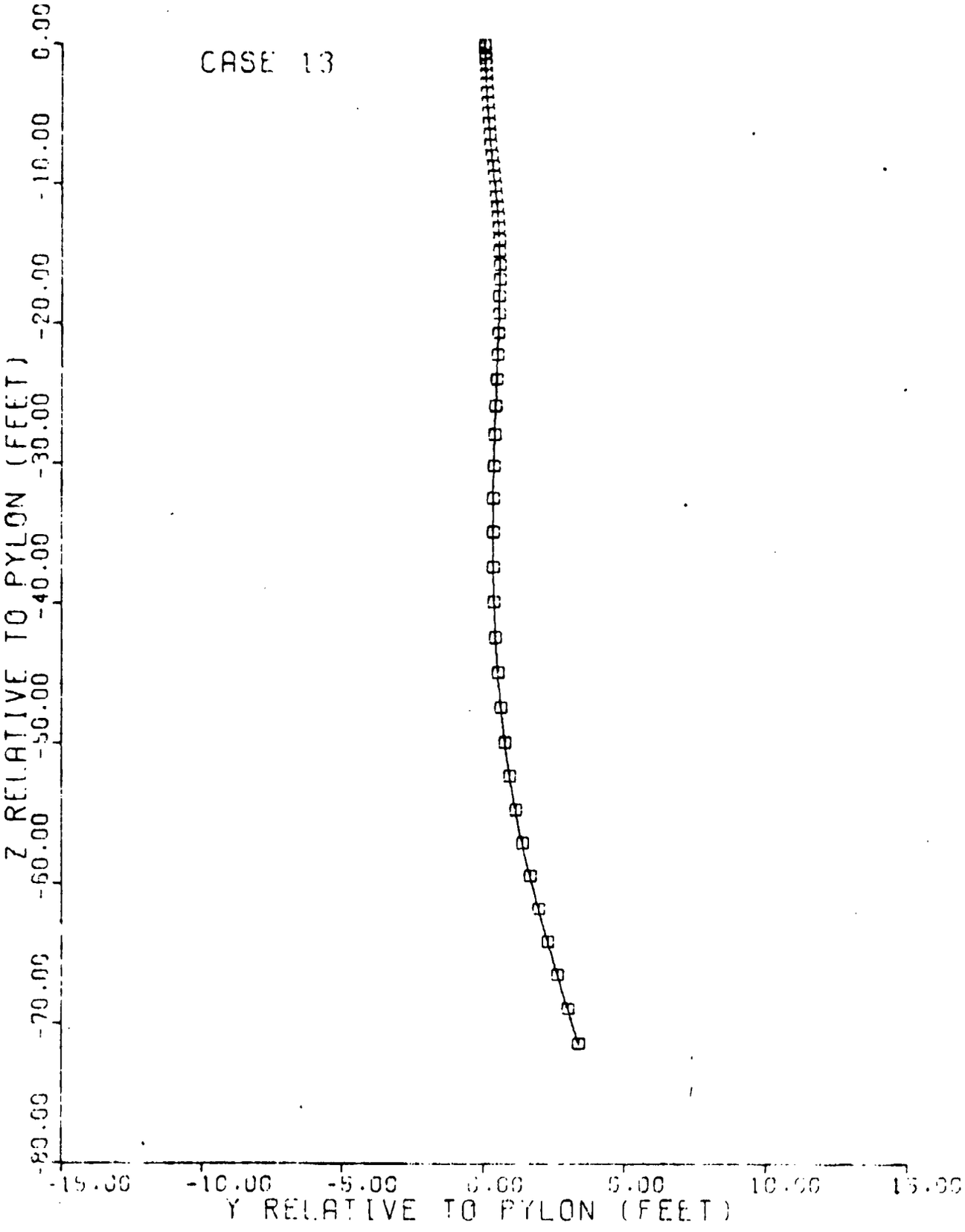

Figure 82. MQM-74C Lateral Separation Trajectory

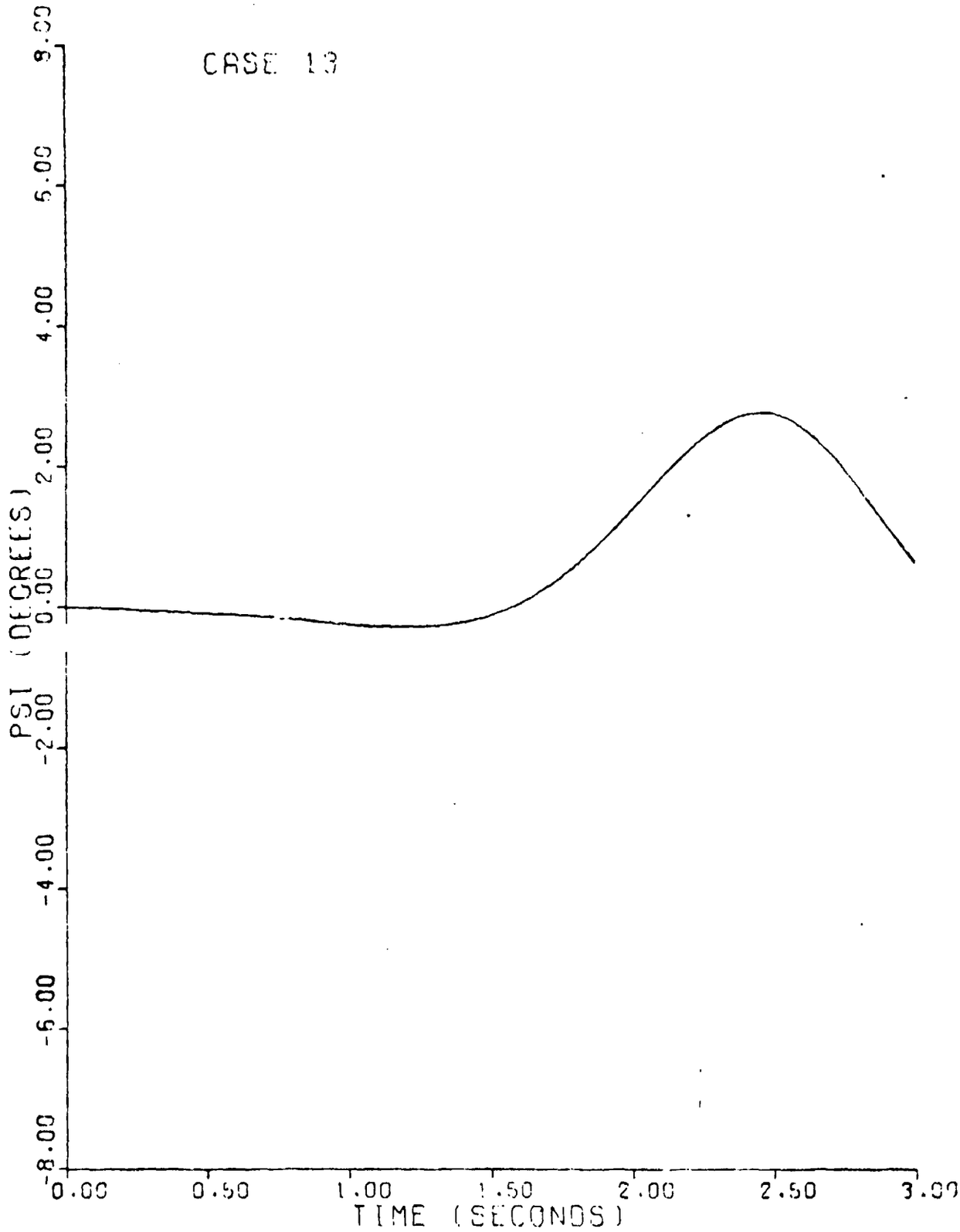

Figure 83. MQM-74C Yaw Time History

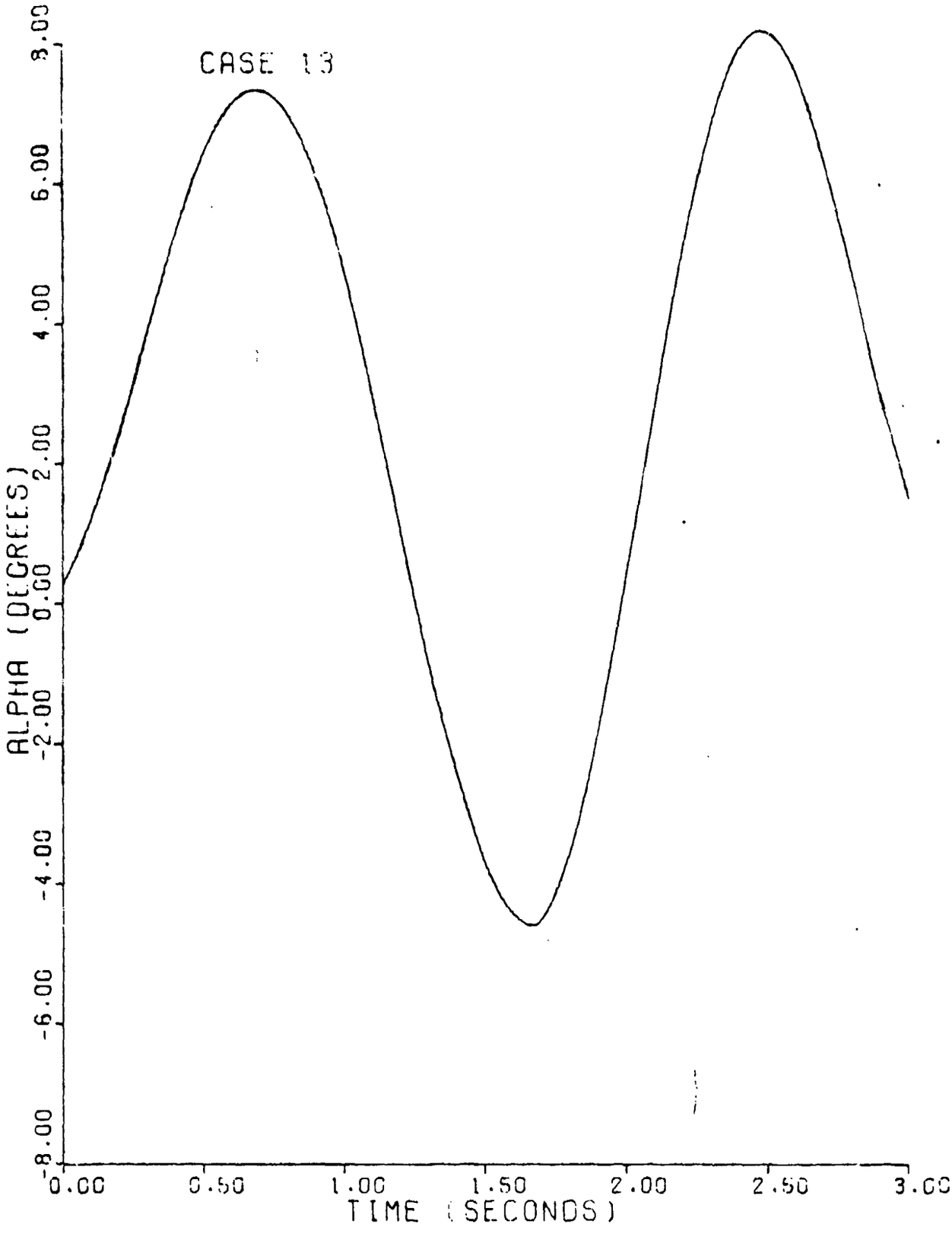

Figure 84. MQM-74C Angle of Attack Time History

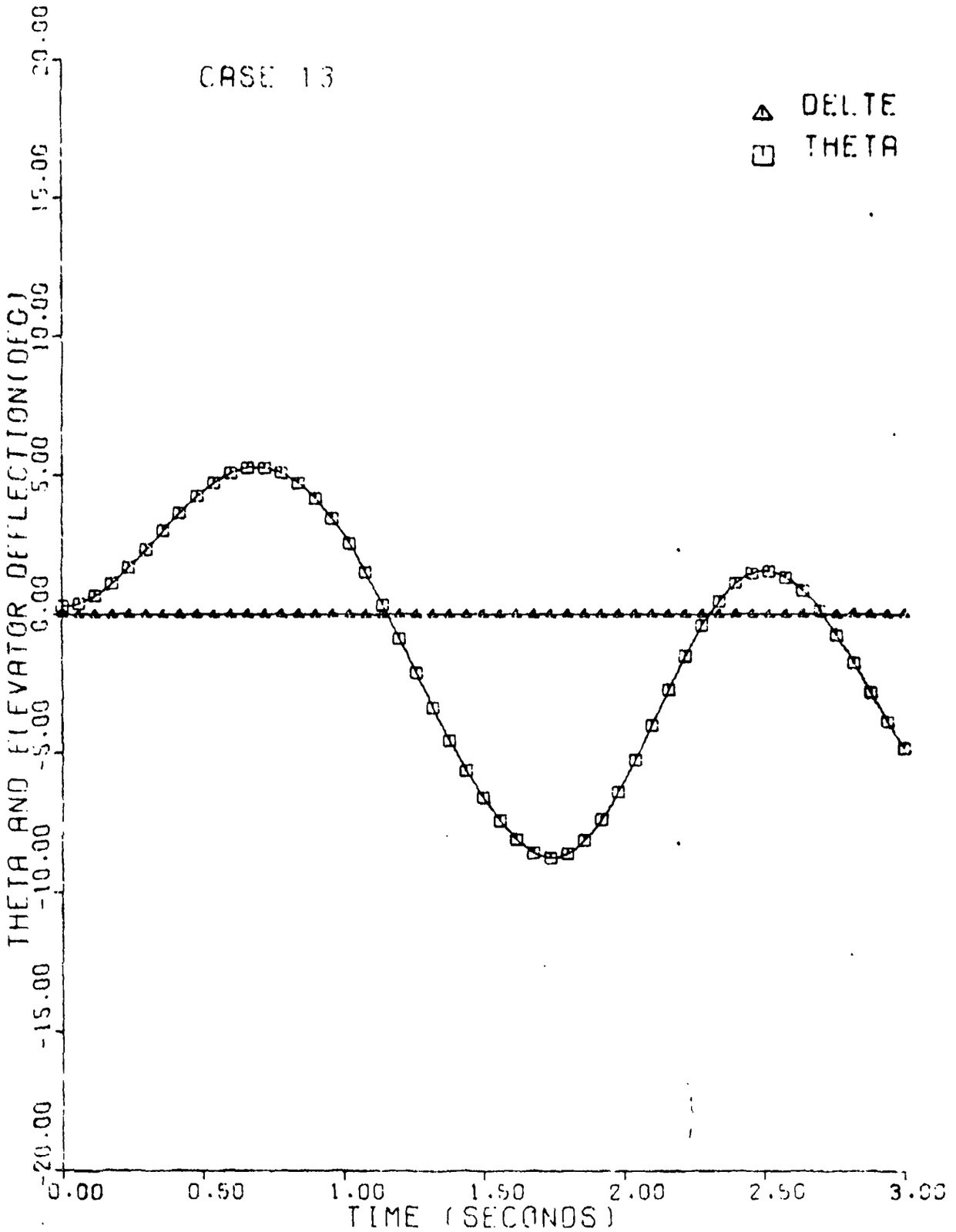

Figure 85. MQM-74C Pitch Attitude and Elevator Deflection Time History

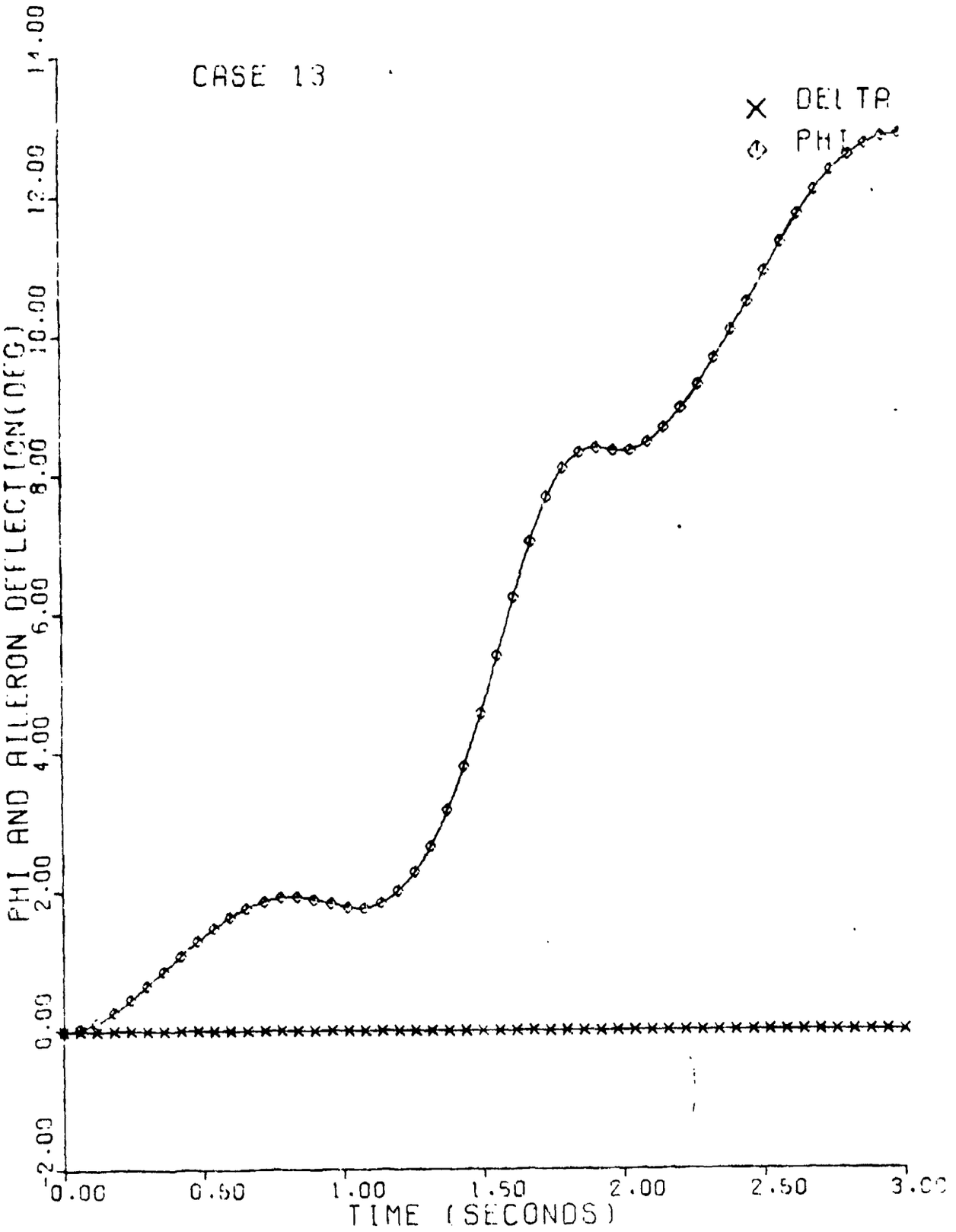

Figure 86. MQM-74C Roll Angle and Aileron Time History

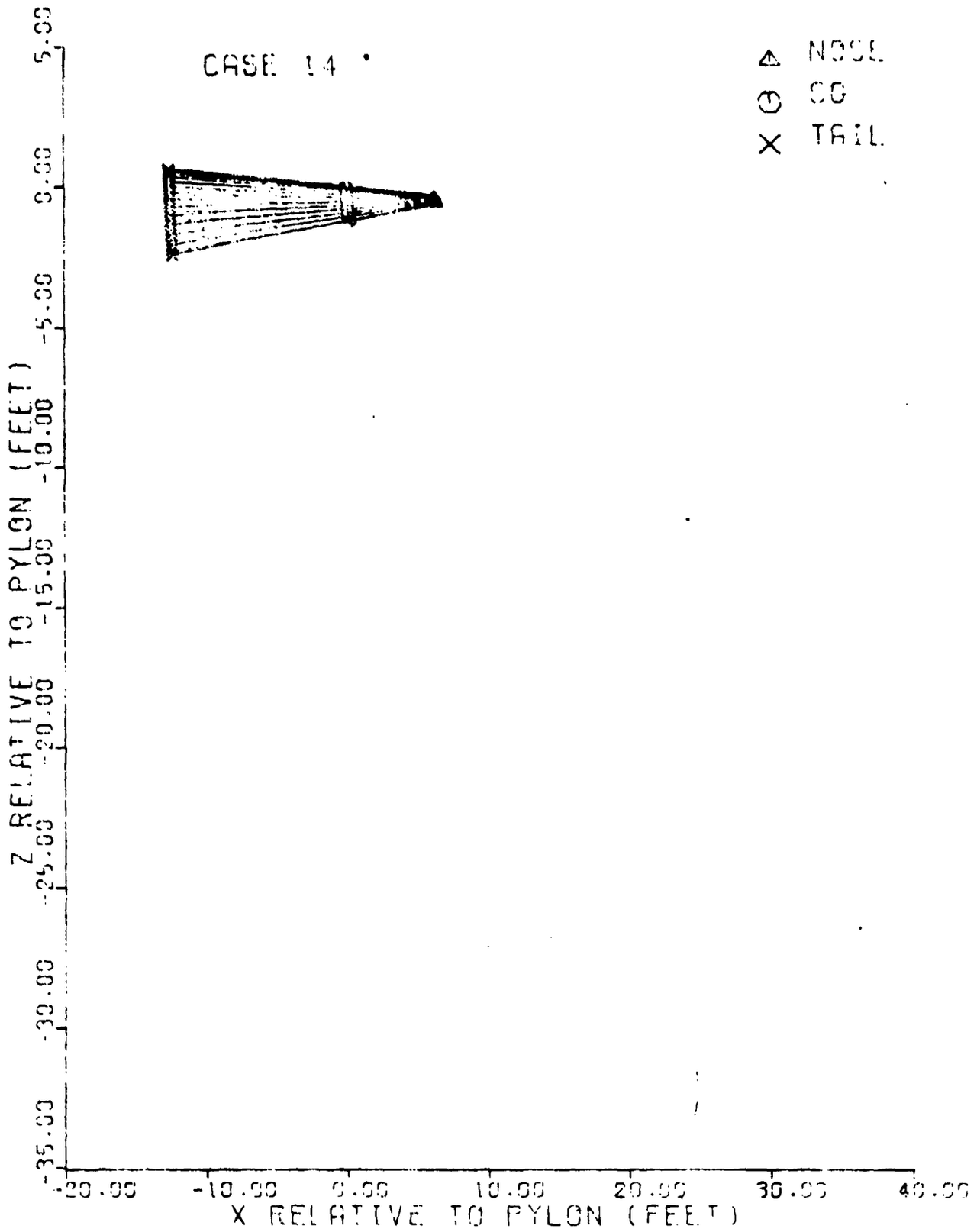

Figure 87. MQM-74C Longitudinal Separation Trajectory

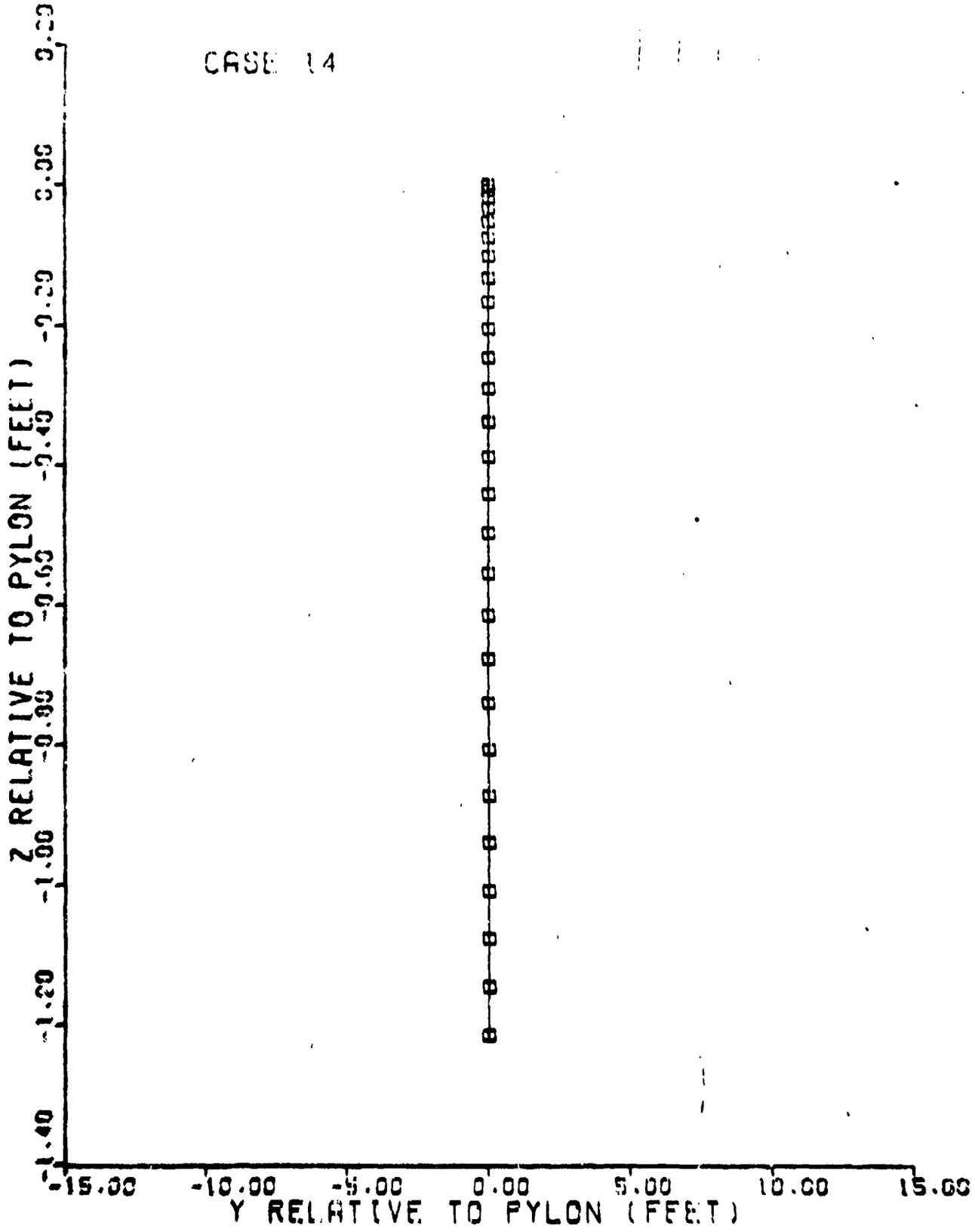

Figure 68. MQM-74C Lateral Separation Trajectory

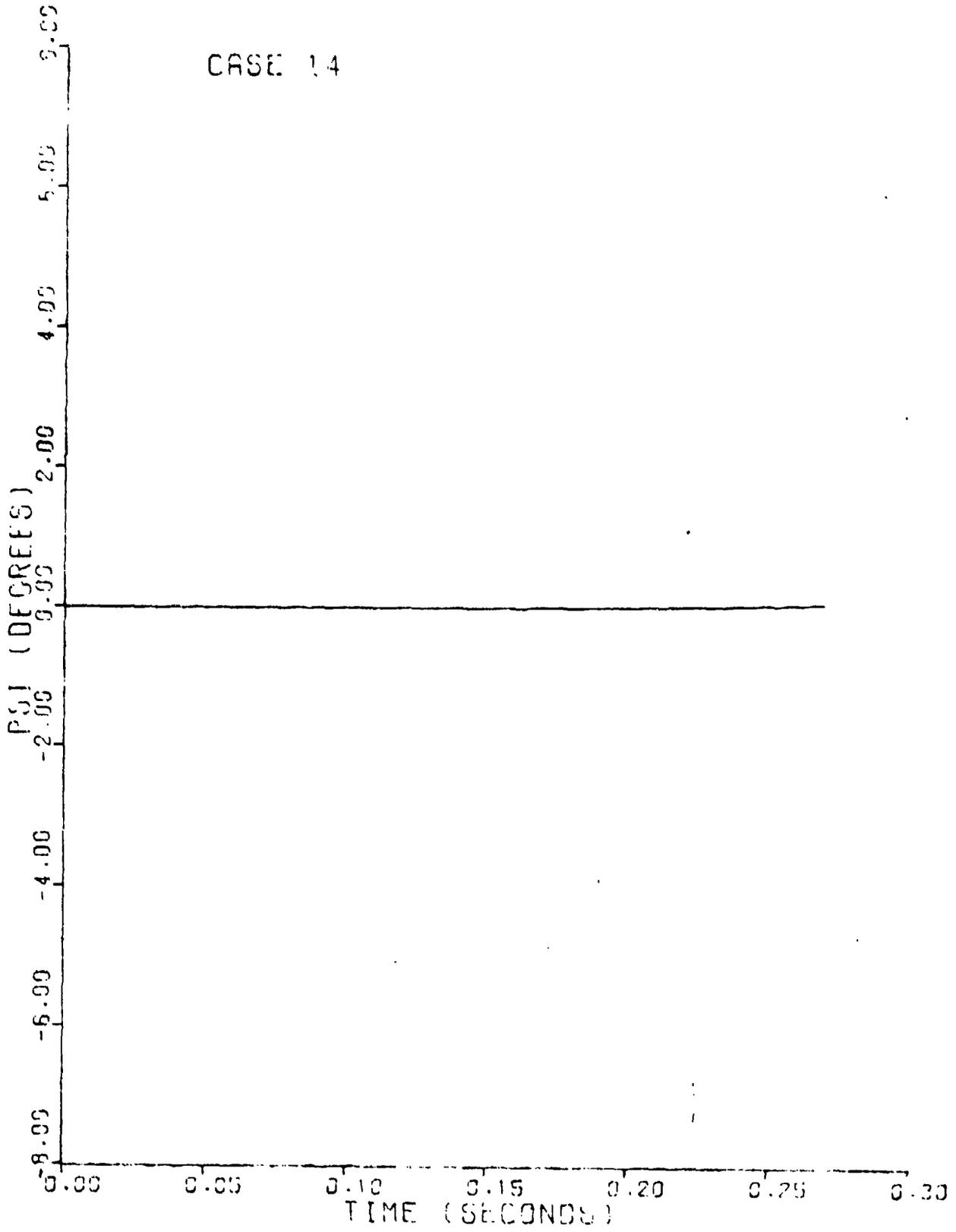

Figure 89. MQM-74C Yaw Time History

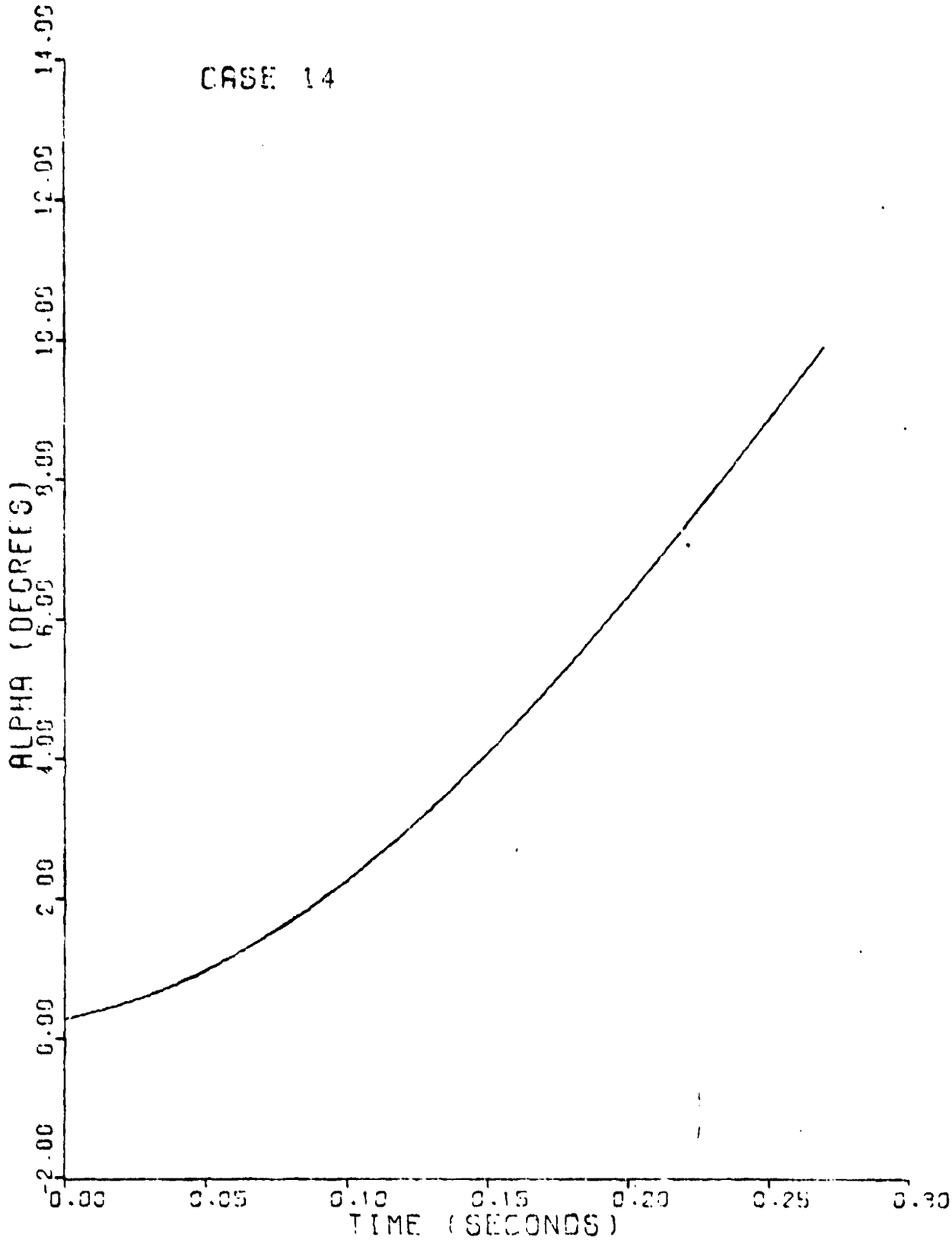

Figure 90. MQM-74C Angle of Attack Time History

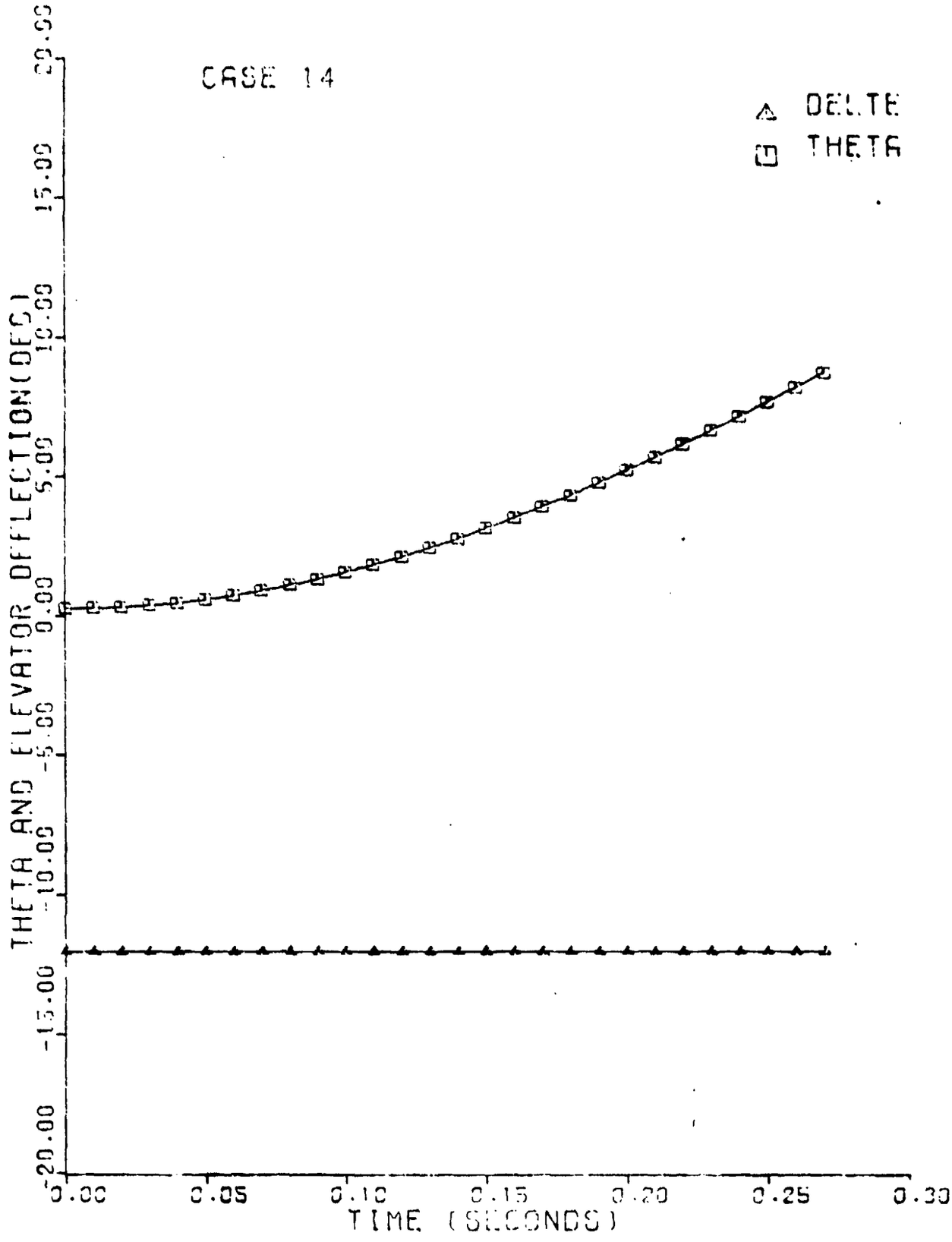

Figure 91. MQM-74C Pitch Attitude and Elevator Deflection Time History

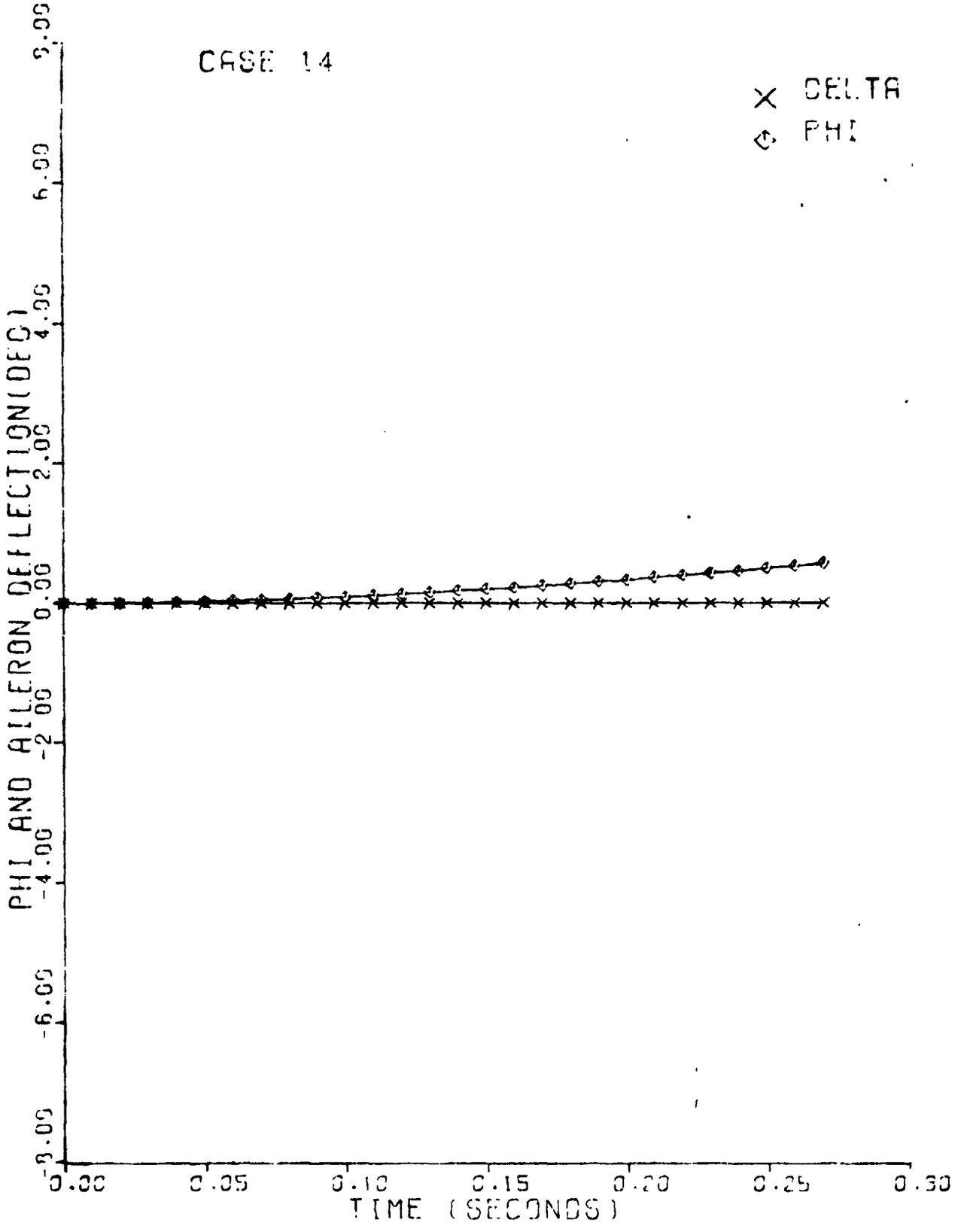

Figure 92. MQM-74C Roll Angle and Aileron Time History

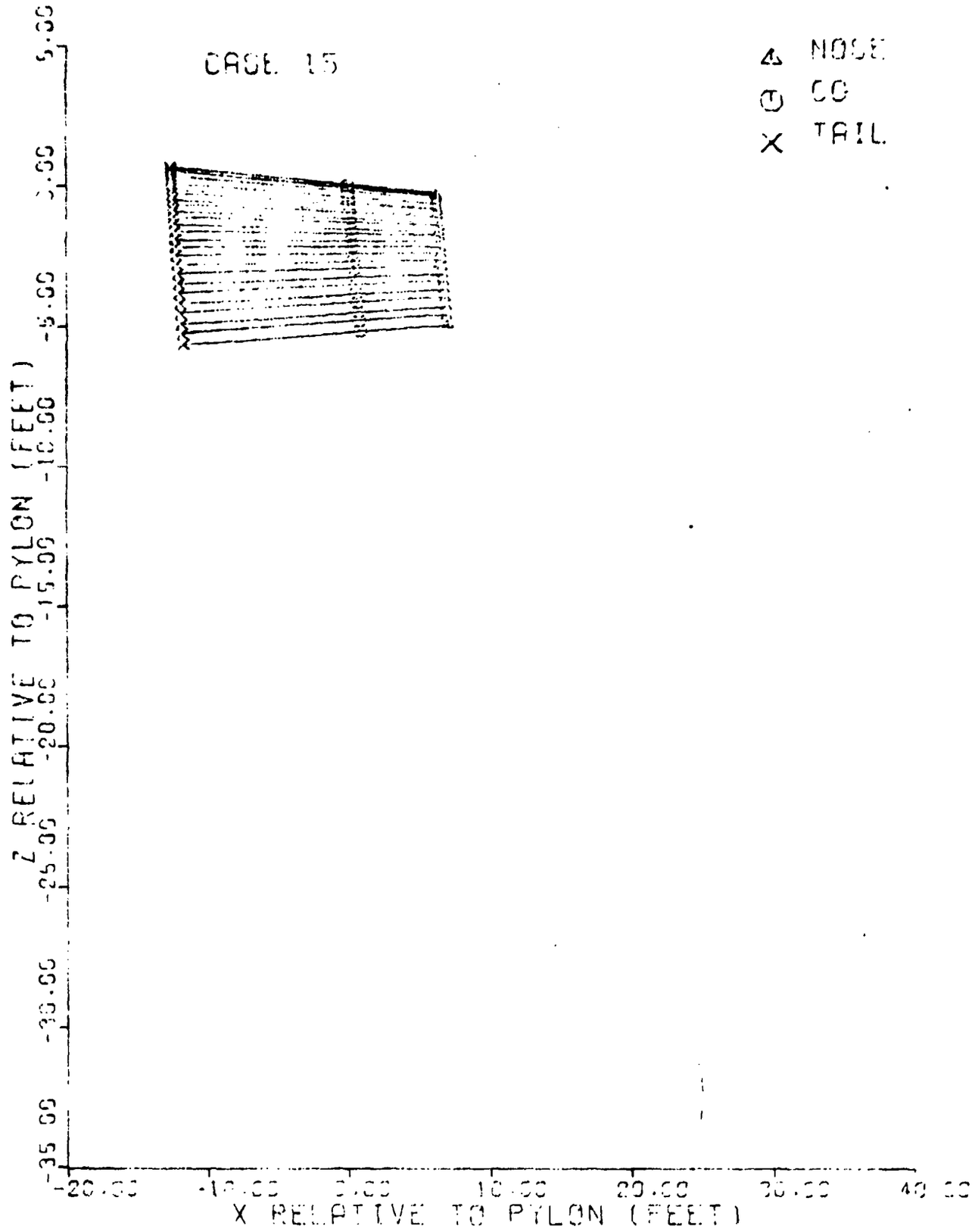

Figure 93. MQM-74C Longitudinal Separation Trajectory

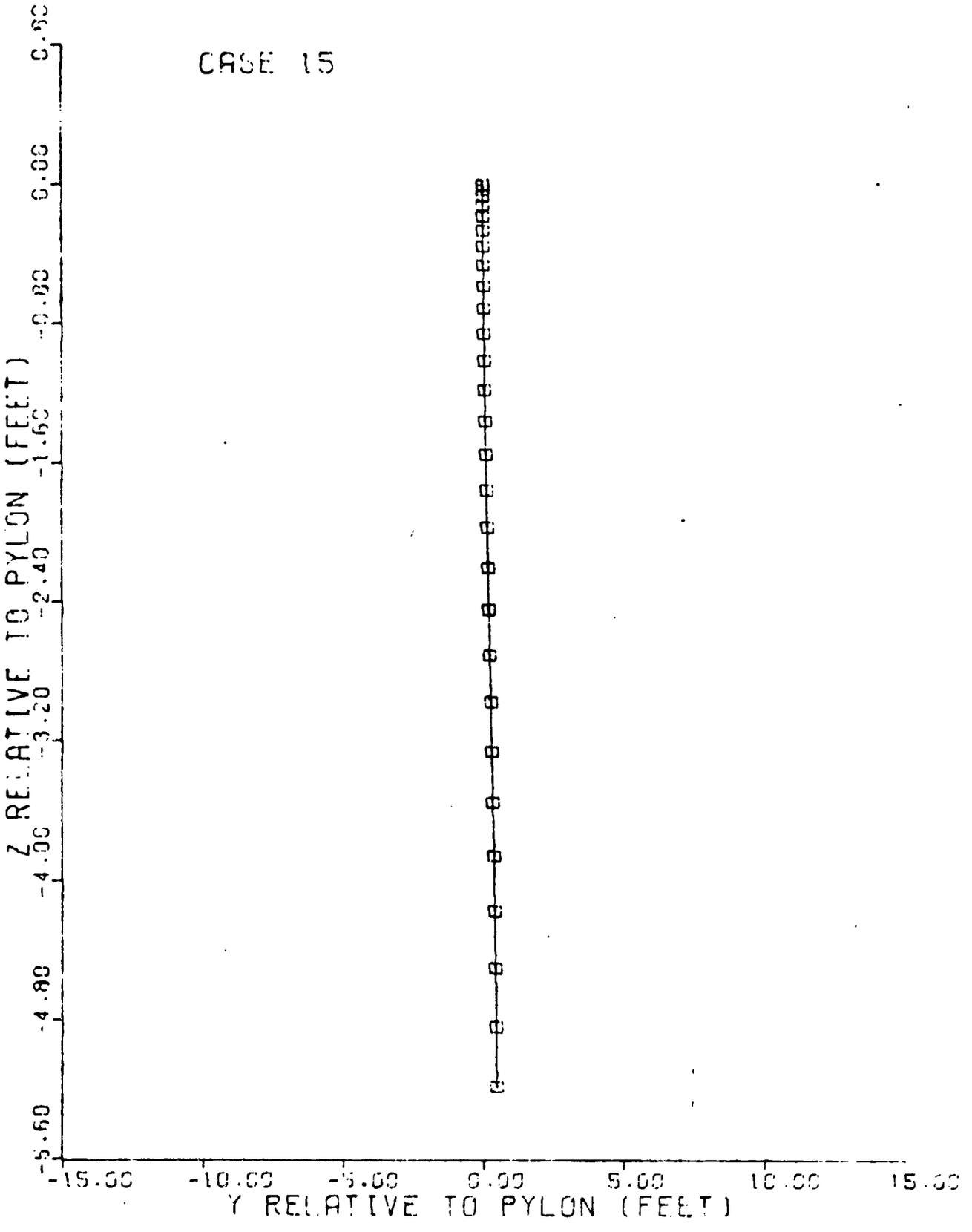

Figure 94. MQM-74C Lateral Separation Trajectory

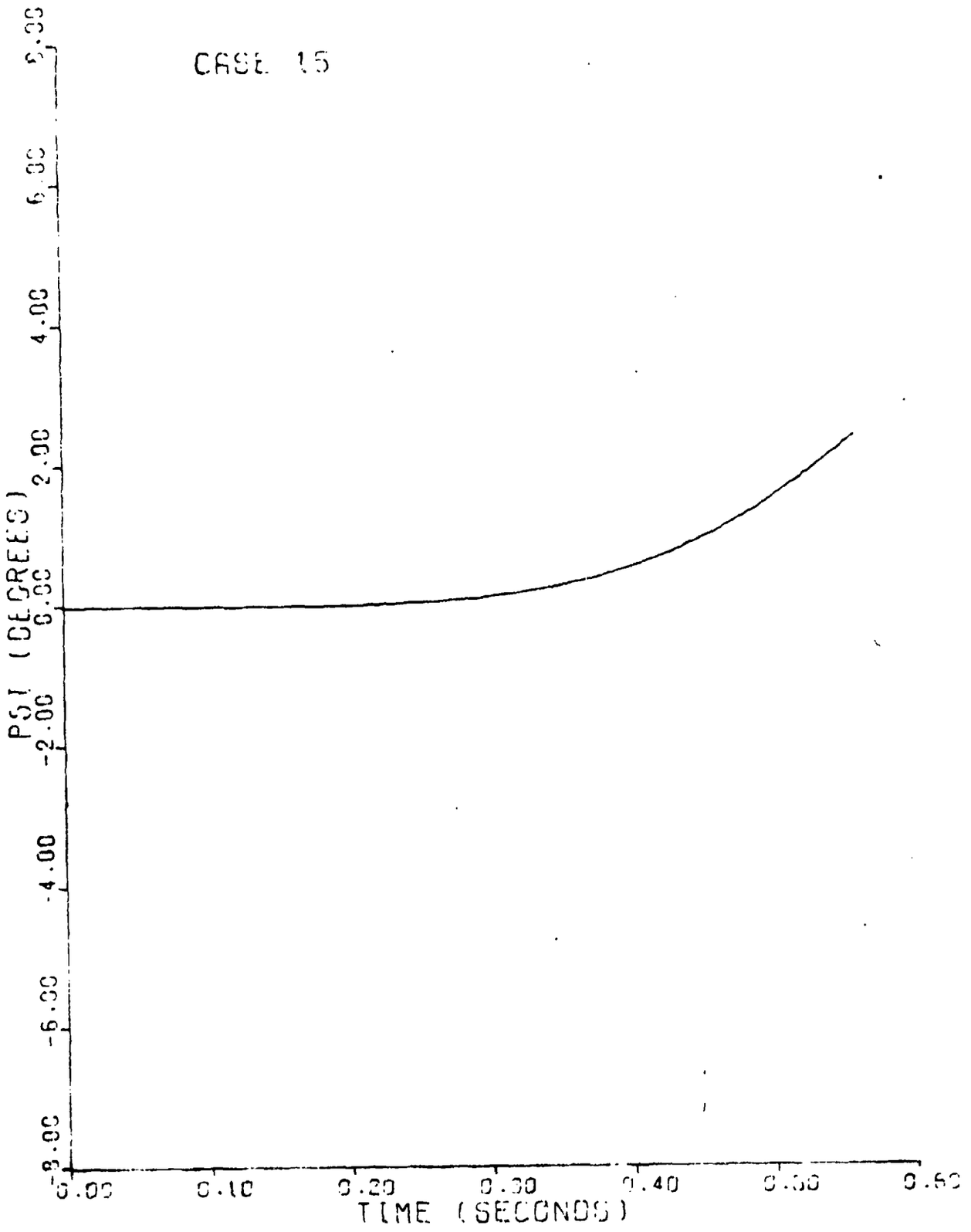

Figure 95. MQM-74C Yaw Time History

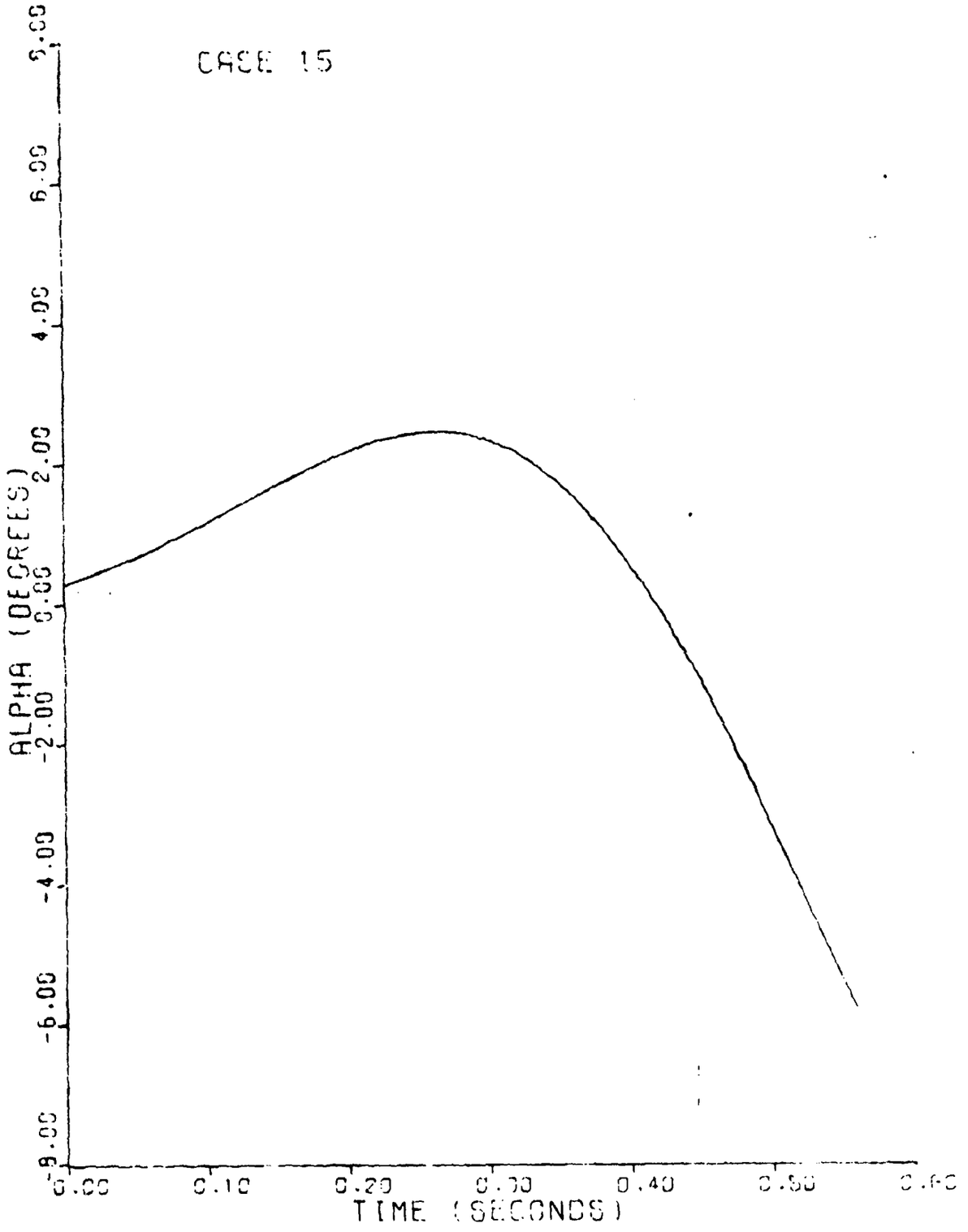

Figure 96. MQM-74C Angle of Attack Time History

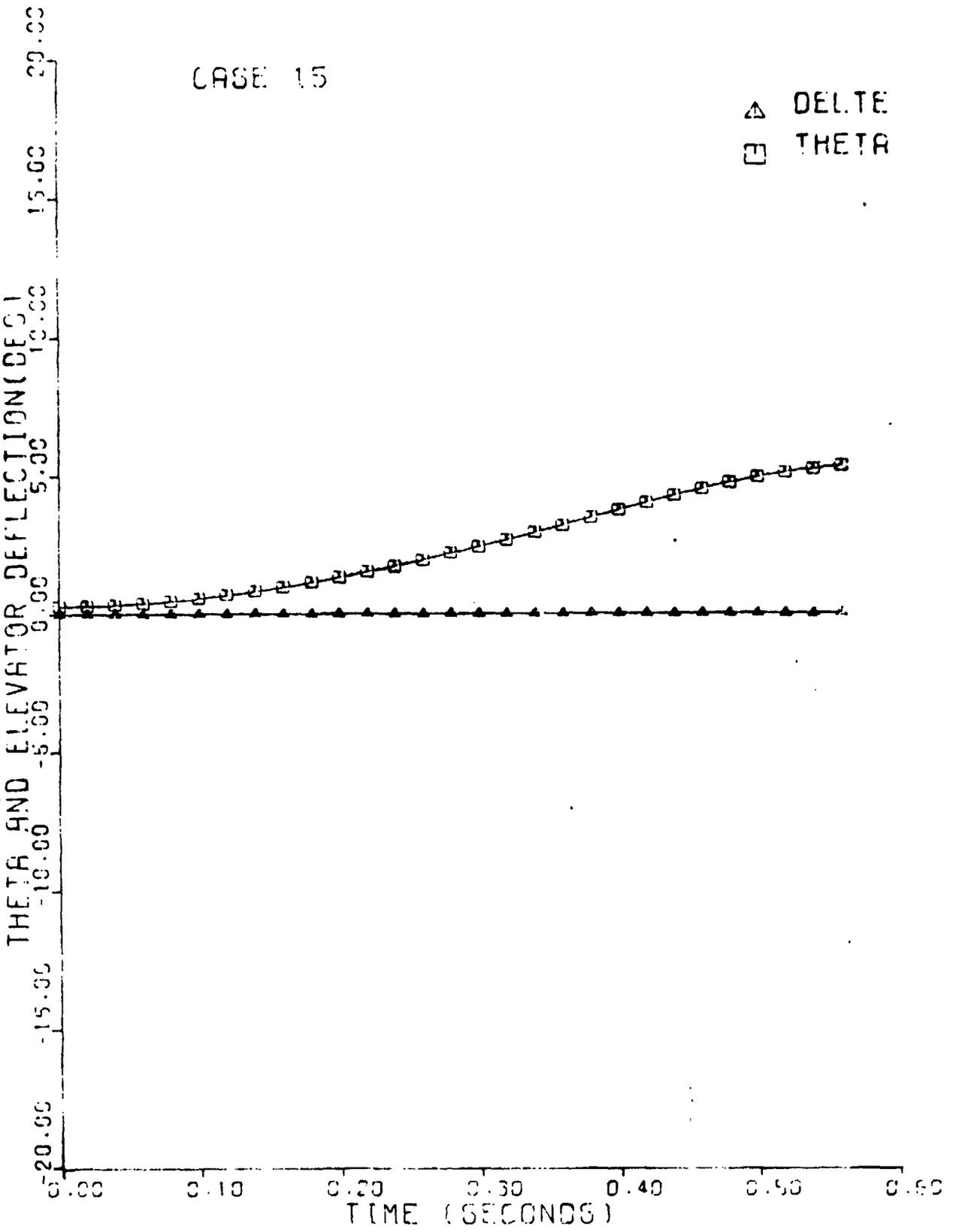

Figure 97. MQM-74C Pitch Attitude and Elevator Deflection Time History

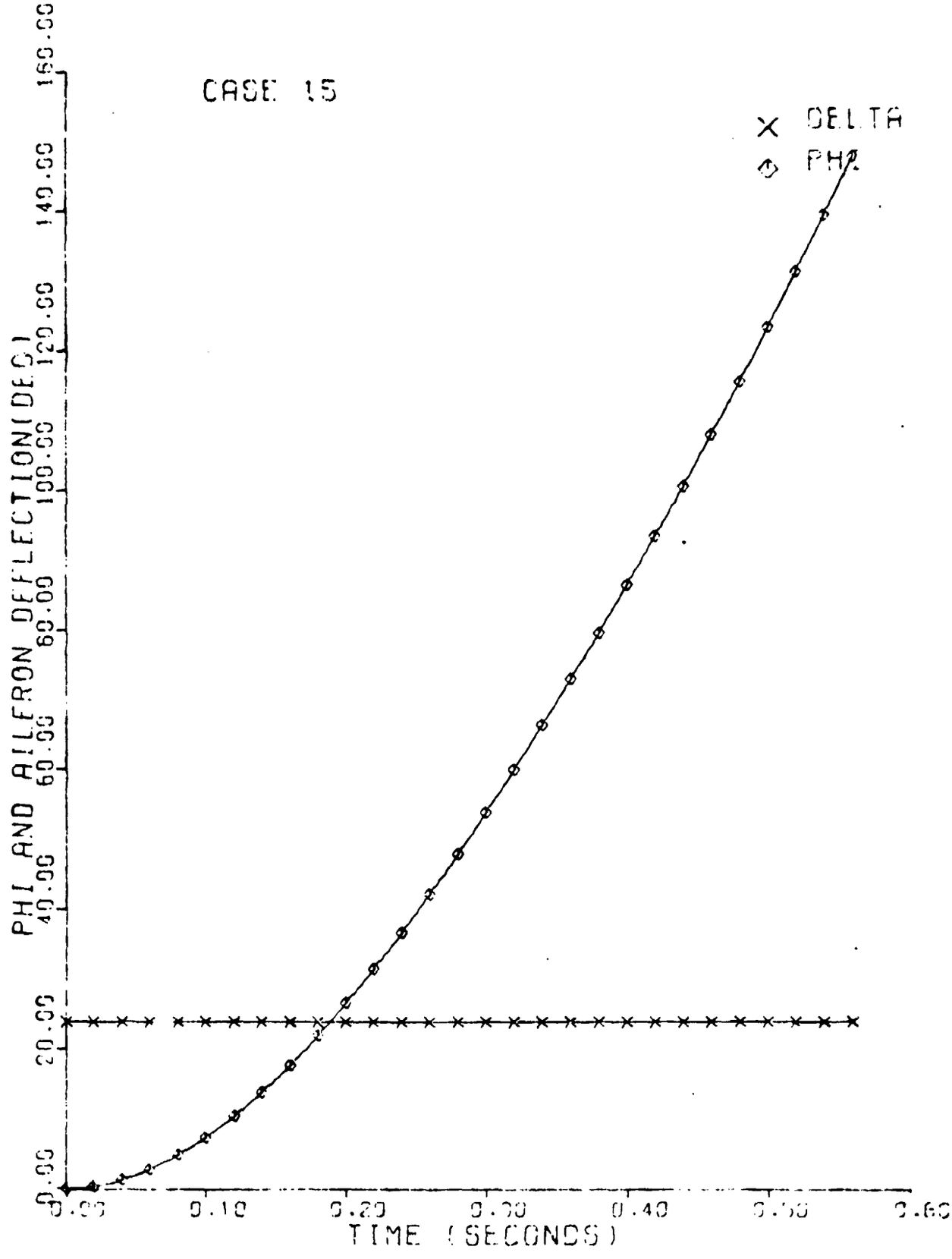

Figure 98. MQM-74C Roll Angle and Aileron Time History

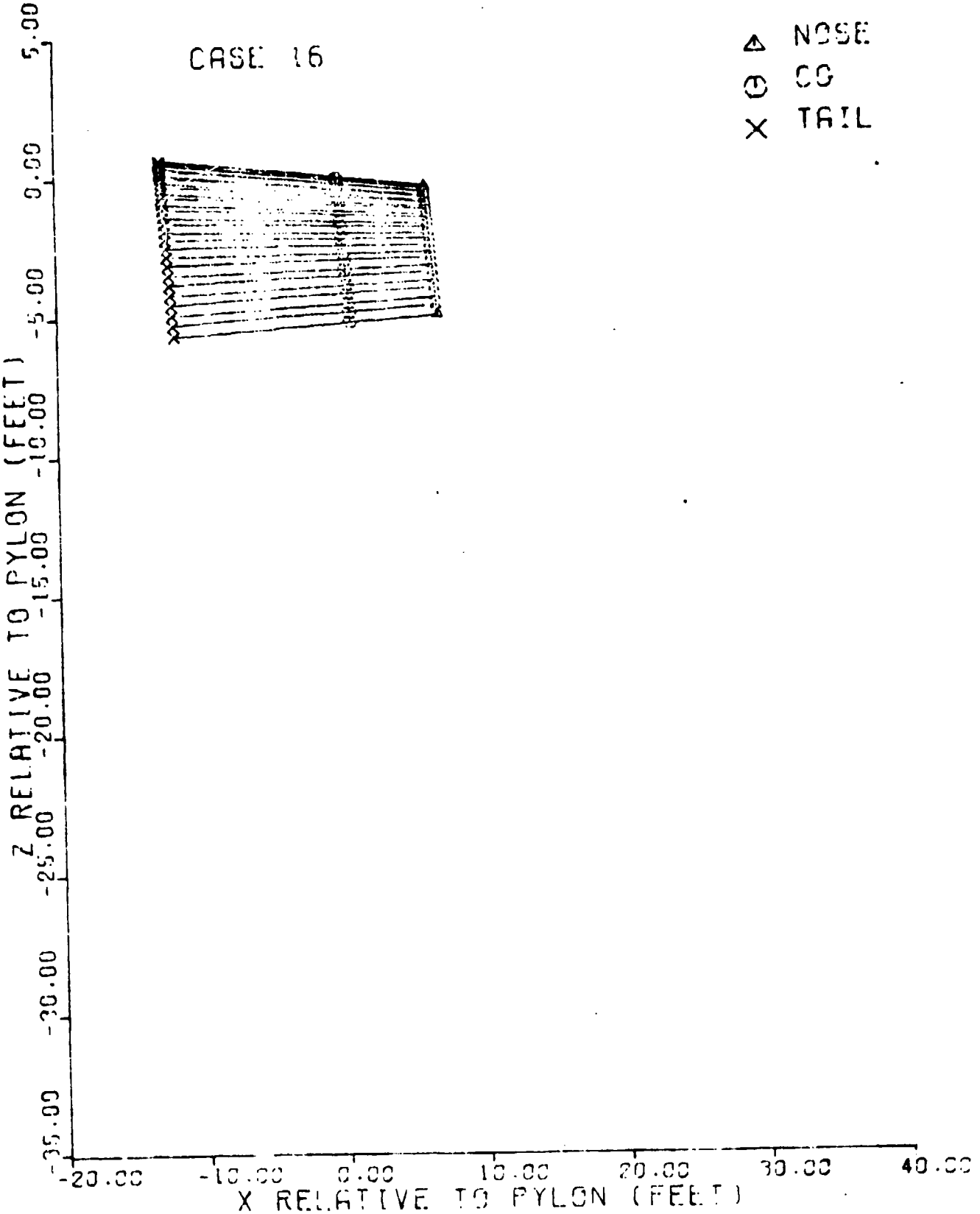

Figure 99. MQM-74C Longitudinal Separation Trajectory

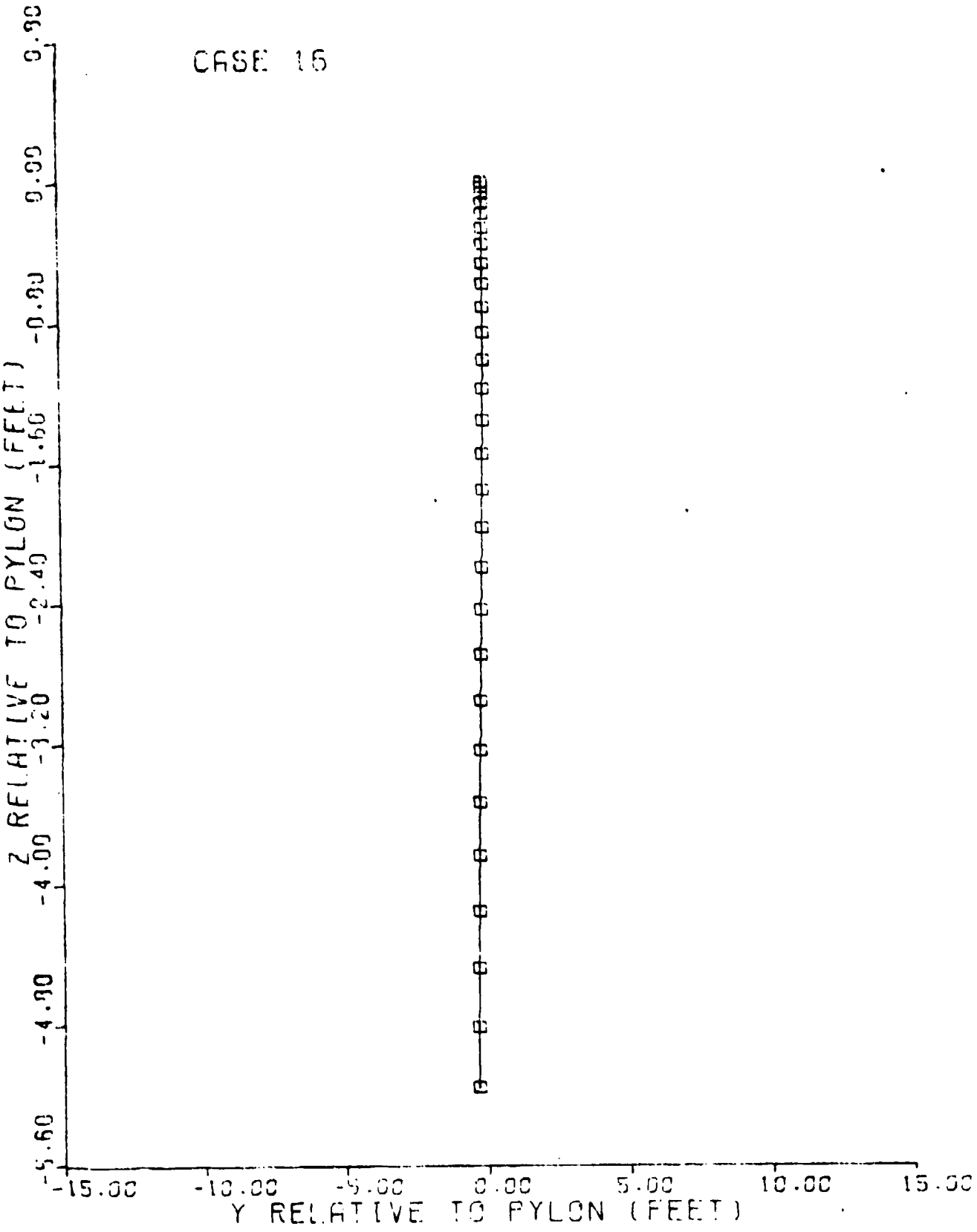

Figure 100. MQM-74C Lateral Separation Trajectory

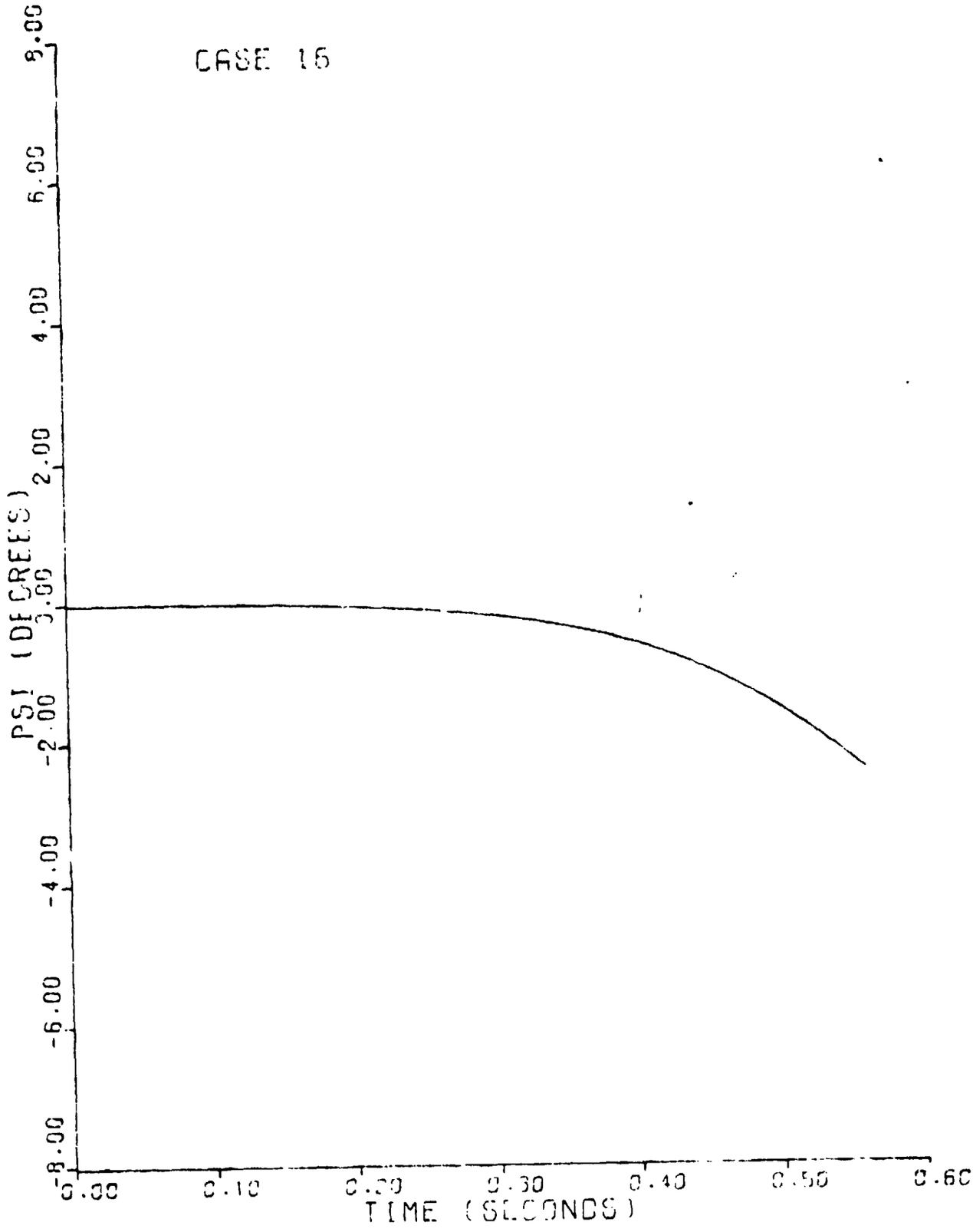

Figure 101. MQM-74C Yaw Time History

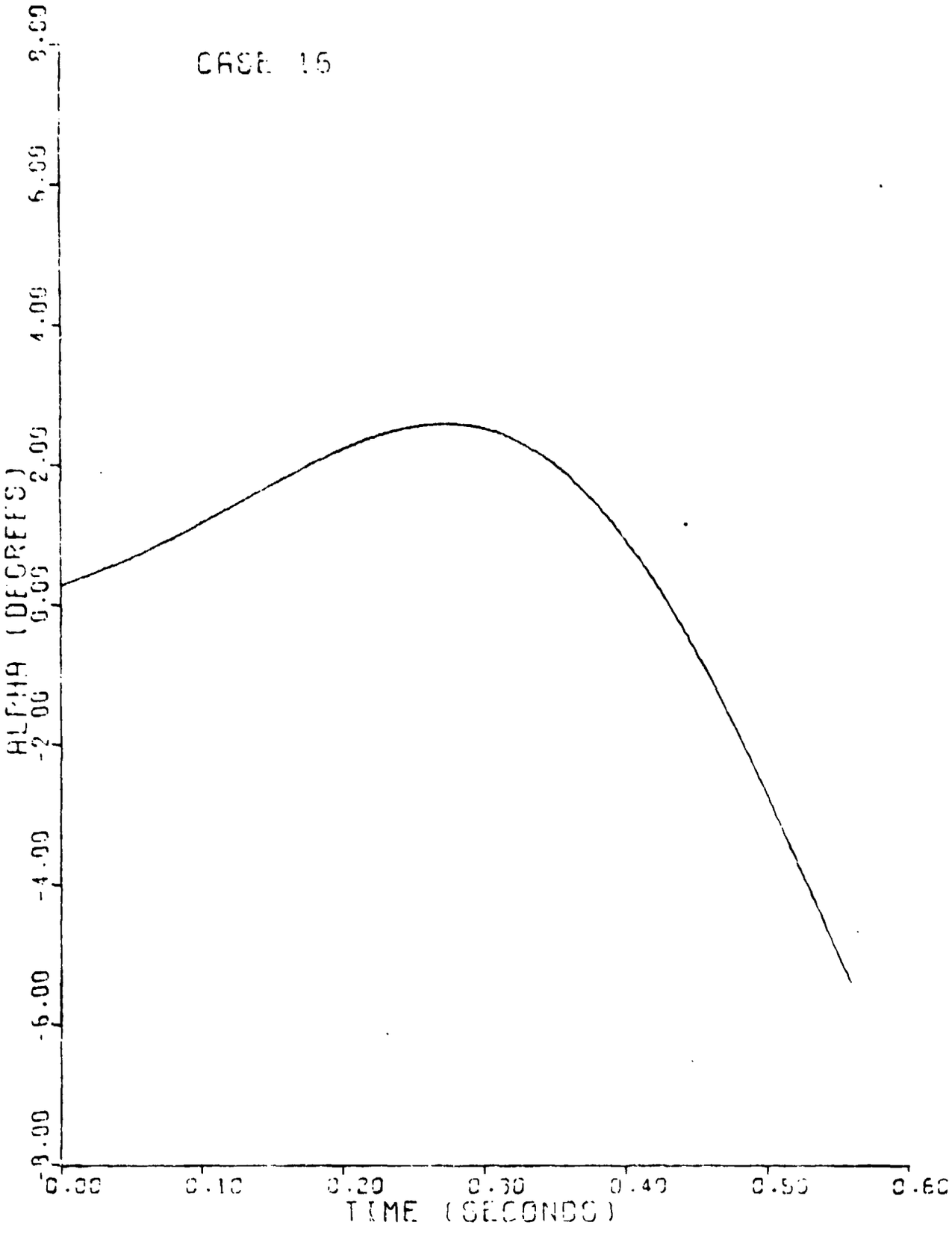

Figure 102. MQM-74C Angle of Attack Time History

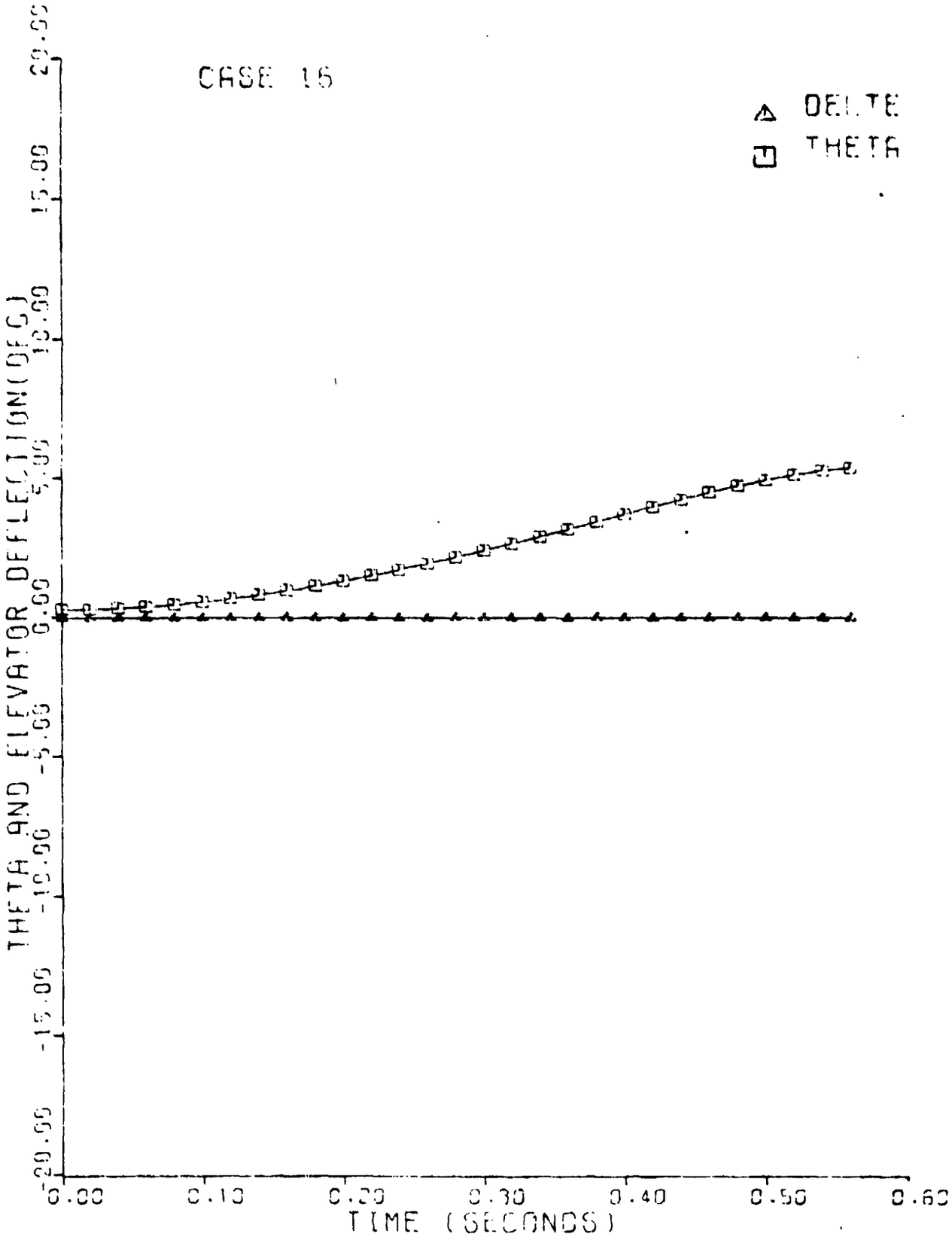

Figure 103. MQM-74C Pitch Attitude and Elevator Deflection Time History

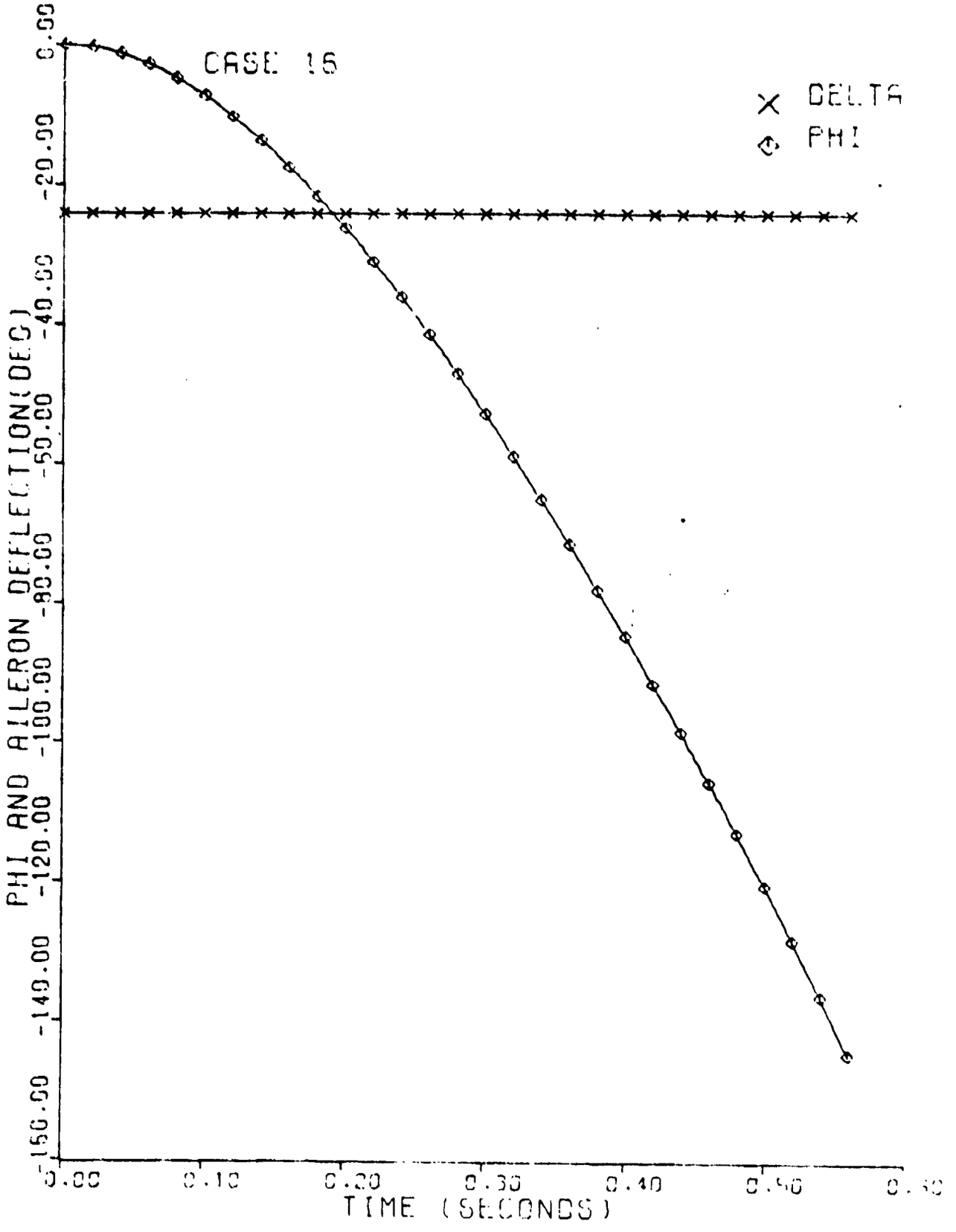

Figure 104. MQM-74C Roll Angle and Aileron Time History

is increasing and developing higher lift for case 2, the negative installed normal force is such that it counters the free stream lift force but only to the increase noted above. Once the target clears the flow field, in approximately 1.5 seconds, the autopilot commands the target successfully to -5 degrees pitch attitude.

AIRSPEED EFFECT

The effect of varying the launch airspeed on target separation from the DC-130 launch aircraft is shown in figures 9 through 26 for an altitude of 10,000 feet. Airspeeds of 160, 200, and 235 knots were investigated. In all cases, as the launch airspeed increases so does the rate of separation of the target from the launch pylon. This separation condition is encountered due to the installed force coefficients, the DC-130A flight condition, and the target installed position on the pylon (-3 degrees with respect to the aircraft fuselage reference line). The installed coefficients vary as the DC-130A flight condition is changed. As the DC-130A flies faster, the angle of attack for a given gross weight and center of gravity location decreases, thereby modifying the installed force coefficients. Thus, in effect, the target installed position and its increased negative angle of attack results in an increased negative installed normal force coefficient. This force coefficient is more prominent than the other installed coefficients and affects the target separation distance from the launch aircraft.

ALTITUDE EFFECT

The effects of altitude variation on target separation were investigated for altitudes of 5000, 10,000 and 15,000 ft, and are presented in figures 27 through 38 and figures 9 through 14. Since previous results showed little difference in separation due to launch airspeed, a nominal value of 200 knots was chosen. These results indicate that as altitude increases so does the separation distance. Initially, however, the target separation distance and pitch rate are larger for the lower launch altitudes than for the higher launch altitudes. The installed normal force coefficient contributes to the increased separation distance at the lower altitude but the target also experiences a large positive pitch rate, because of the larger dynamic pressure, which effectively offsets the separation distance gain at the lower altitudes. Figures 39 through 41 show the pitch rate and figures 31, 13, and 37 show the pitch attitude for the three noted altitudes. At the higher altitude, the increased pitch down attitude (when compared to the lower altitude) results in a steeper negative flight path. This steep flight path angle then effectively increases angle of attack because the target is dropping faster as a result of lower dynamic pressure. Figures 42 through 44 show the flight path time history and figures 30, 12, and 36 show the angle of attack time history.

AUTOPILOT PITCH COMMAND EFFECT

The effect of increasing autopilot pitch command from zero to -8 degrees on the separation characteristics was examined. The results are as one would

expect; the larger negative pitch command improves the separation characteristics. Figures 9 through 14 for the -5 degrees pitch command and figures 45 through 57 for zero and -8 degrees pitch command, respectively, present the results.

FLOW FIELD CORRECTION FACTOR

The flow field information was compiled from wind tunnel data and analytical estimates as discussed earlier in this report. To assure more confidence in the flow field data, downwash angle correction factors of ±2 degrees were investigated to determine their effects on the separation characteristics. The installed aerodynamic coefficients were determined for the two correction factors and are noted in Table II for cases 9 and 10. Upwash angle, -2 degrees, indicated a reduction in separation distance when compared to the downwash angle, 2 degrees. These results are presented in figures 9 through 14 for no flow field correction factor and figures 57 through 68 for the noted downwash angles.

SIDESLIP ANGLE EFFECT

The effect of launch aircraft sideslip angle on the launch trajectory of the target was also examined. This mode of launch was selected to illustrate an out of pitch plane separation. A 5 degree sideslip condition was chosen to be a representative launch flight condition. Figures 69 through 74 illustrate the results of the analysis of sideslipping effects. The parameter to note is lateral displacement, figure 70, which shows that the target is pushed inboard from the pylon but the results are minor. The effect of sideslip on vertical and longitudinal displacement of the target is much more evident than the small lateral effect shown.

AUTOPILOT AND ENGINE FAILURE MODES EFFECT

The previous separation analyses were performed with the autopilot and engine both operating. The possibilities of more adverse situations might prevail during separation, and these were taken into consideration. Several critical contingencies were investigated, as follows:

1. Autopilot inoperative and engine off

2. Autopilot inoperative and engine on

3. Elevator fixed in the full-up position with the engine on

4. Aileron fixed in two full positions; one position generates a clockwise roll of the target, and the other position generates a counterclockwise roll of the target, with engine on.

Figures 75 through 80 show the results of the simulation in which the autopilot was inoperative and engine power off (case 12, Table (II). The trajectory results show that the target clears the pylon and drops back from its installed position. Since the target is statically stable, a pitch down attitude is observed without large oscillation. (See figure 79). The more critical separation condition of autopilot inactive with engine on (case 13, Table (II) is

shown in figures 81 through 86. Here again, the target safely clears the launch pylon. With the engine power on, the vehicle is no longer statically stable and thus the target experiences pitch attitude and angle of attack oscillations (see figures 85 and 84). In addition, the engine produces a roll torque that forces the target to roll unstable (see figure 86). However, these target angular oscillations do not interfere with the launch aircraft.

Results from the simulated malfunctioning autopilot control system, actually a simulation of locked control surfaces at their maximum travel position limits, are given in figures 87 through 104. The elevator surface locked in full up position case (case 11, Table II) shows that the target clears the pylon. Due to the full elevator deflection, the target pitches up in an unstable fashion. Figures 87, 88, 90 and 91 show the separation trajectory, angle of attack time history, and pitch attitude time history, respectively. Simulation of the ailerons locked in position that causes the target to roll clockwise for one case (case 14, Table II) and roll counter clockwise for the other case (case 15, Table II) indicates that separation may be marginal. The trajectory separation shown in figures 99 and 100 indicates that the target clears the pylon. However, during that time the target rolls approximately 150 degrees, see figures 98 and 104. This results in the wing clearing the pylon by about 3.5 feet. Considering the method by which the flow field was determined, the clearance is not adequate to justify launching the target with ailerons locked in a fully deflected position.

CONCLUSIONS

The following conclusions were reached based on the digital simulated analysis:

1. The MQM-74C target separation characteristics were found to be acceptable for the range of DC-130A launch aircraft flight conditions normally used for air launching other powered aerial targets, such as the BQM-34 type targets.

2. The simulation with the ailerons at their fully deflected positions indicates that target separation characteristics may be marginal. Because of the extreme aileron positions, the target experiences high roll rates and subsequent roll angles of 150 degrees in a period of 0.5 second, which results in the target wing clearing the DC-130A launch pylon by only 3.5 feet.

3. The target separation with the elevators at their fully deflected positions presents no problem with regard to aircraft contact. However, the target is unstable for this launch mode.

4. The results of launching the target at various true airspeeds of 160, 200, and 235 knots at 10,000 feet show that as launch airspeed increases so does the rate of separation. However, the separation distances for the three airspeeds show small differences.

5. The effect of altitude variations, from 5,000 to 15,000 feet, on target separation for a nominal launch airspeed of 200 knots show that as altitude increases so does the separation distance.

6. DC-130A aircraft flow fields effects on target separation characteristics, including downwash correction factors of ±2 degrees were not appreciable.

7. Launching the target while the DC-130A aircraft is sideslipping 5 degrees presents no problem with regard to safe target separation.

RECOMMENDATIONS

1. It is recommended that the MQM-74C be launched from the DC-130A aircraft at a nominal flight launch condition of 200 knots true airspeed and 10,000-foot altitude.

2. Launching the target with its ailerons fully deflected from the DC-130A aircraft is not recommended.

3. Provisions should be provided in the DC-130A aircraft to assure the proper operating conditions of the MQM-74C target prior to launch.

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